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The Marine Engineer

AND NAVAL ARCHITECT.

Editorial and Publishing Office—
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APRIL, 1923.

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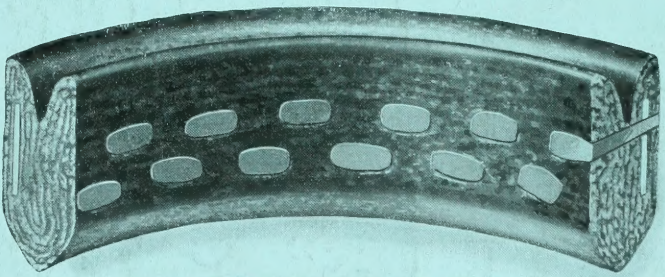

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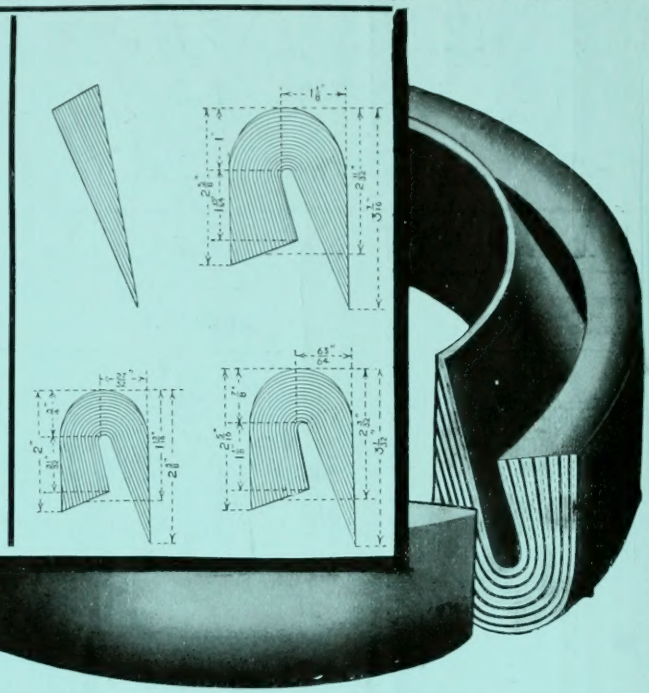

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The Marine Engineer
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MECHANICALLY PROPELLED SHIPS — MARINE ENGINEERING WORKS
DIESEL AND OTHER OIL ENGINES — WELDING & MECHANICAL REPAIRS
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The Editor will be glad to consider original articles and paragraphs on all subjects indicated by the title. Short practical articles based on the sender's own experience and illustrated by photographs or drawings are desired.

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Ir. S. Visman, naval architect, has been appointed Architect to the Royal Dutch Navy.

Sir Charles E. Ellis, G.B.E., K.C.B., one of the managing directors of John Brown & Co. Limited, Sheffield, has been elected Master of the Shipwright's Company.

Mr. James Goodier, who died at Birkenhead on February 19 at the age of 67, was 42 years in the employ of Cammell Laird & Co. Limited, and for 20 years was foreman engineer.

The death has occurred at Baarn of Mr. Johs. F. Wijsmullers, at the age of 46 years. He was the founder and managing director of the N.V. Bureau Wijsmuller Scheepvaart, Transport and Zeesleepvaart My., The Hague.

The death occurred at Plymouth recently of Mr. George Crocker, C.B., the well-known naval constructor. He became a shipyard apprentice in 1869, and was selected in 1884 as constructor under the Indian Government. Returning to England in 1897, he became constructor at Chatham Dockyard, and was later chosen by Sir William White as inspector of overseers for the ships building under the Naval Defence Act of 1888. In 1890 he was appointed chief constructor at Devonport, and in 1895 became chief constructor at Chatham. In 1897 he went back to Devonport as Civil Technical Assistant to the Admiral Superintendent. He spent 46 years in Admiralty service, from which he retired some years ago.

Mr. A. L. Ayre, O.B.E., J.P., has been appointed Chairman of the Burntisland Shipbuilding Company Limited, in succession to the late Sir William Robertson.

The death occurred suddenly on March 11 of Captain H. B. Hooper, R.I.M., Vice-Chairman of the General Steam Navigation Company.

Mr. George Nixon Patterson, retired shipowner, of Newcastle-on-Tyne, who died in January last at the age of 79 years, formerly one of the principals of the Tyne Dock Engineering Company, South Shields, and for some years manager of a dry dock at Swansea, left gross estate of the value of £18,247, with net personalty £16,276.

Mr. R. Y. McIntosh, founder of the firm of R. Y. McIntosh & Co., has just celebrated his 50th year of business life. He commenced work with the firm of R. & W. Hawthorn, now R. & W. Hawthorn, Leslie & Co. Limited, Newcastle. After remaining with them for 18 years, he left to begin business for himself as an engineers' merchant, and for 32 years he has represented manufacturers of shipbuilding and engineering specialities on the north-east coast.

Mr. John A. West has been appointed to the Admiralty inspecting staff at Birkenhead as Boiler Overseer. Mr. West received his early training at Portsmouth Dockyard and spent some time as Overseer at Birkenhead when the oil-fired boilers of the experimental destroyers *Swift* and *Cossack* were being manufactured in 1907; since then he has been on the Clyde carrying out similar inspection duties in connection with warship contracts. He is to supervise the manufacture of the main boilers for H.M.S. *Rodney* at Cammell Laird's works.

Mr. Frank Adamson, a well-known surveyor to Lloyd's Register of Shipping, died suddenly of acute gastritis on February 20 at his residence, 6403 Lebanon Avenue, Philadelphia, Pennsylvania. Mr. Adamson served his apprenticeship with Wm. Gray & Co., West Hartlepool. For a time he was chief engineer with Sivewright, Bacon & Co., West Hartlepool, and the United Fruit Company, and Superintendent Engineer in Baltimore for Phillips, Phillips & Co., London. For the past eight years he had been an engineer-surveyor for Lloyd's at Philadelphia.

Mr. F. W. Bardens, Superintendent to the Gould Steamships and Industrials Limited, Cardiff, died at Penarth on March 8, following an operation. He was for many years Superintendent Engineer to Farrar, Groves & Co., London. Following the sale of the fleet to Goulds, he was appointed Superintendent to the purchasing company and took up his residence in Penarth about three years ago. Mr. Bardens was well known in the Bristol Channel where he had charge of extensive repair jobs, also in the North of England, having been responsible for the designing and superintending the building of a large number of steamers.

The death has occurred of Mr. W. M. Alston, retired chief engineer of the Clyde Navigation Trust. Mr. Alston was a native of Australia, was trained as civil engineer in Glasgow, and joined the staff of the Clyde Trust early in life. Several docks and quays were constructed under his supervision, and a large amount of general harbour reconstruction. Mr. Alston became chief engineer in 1910, and carried out many important maintenance works, and was responsible for the designs of the large new docks which are to be constructed at Shieldhall. He was connected with the Clyde Navigation Trust for about 55 years, and retired in 1918.

EDITORIAL.

OBSERVATION—INVENTION—ENTERPRISE.

IT has been said that sufficient credit has not been given to owners for their enterprise in putting to the test of practical experience the ideas and inventions which careful observation have brought about. Owners, if they had been conservative, might quite well have said "What has paid us in the past will suffice for the future." But, fortunately, that attitude has not been adopted by many, and the few who have been dilatory in moving with advancing times have ultimately been compelled to modernise their ships so as to ensure economical transit and their share of trade. An interesting case of careful observation, associated with commercial enterprise, is related of canal navigation of a hundred years ago. It concerns the phenomena of abnormal humps and hollows in the resistance curves of vessels in shallow waters. Scott-Russell, in a lecture to the Royal Society of Edinburgh, in 1840, on "The Laws of Certain Hydrodynamical Phenomena" tells the following incident: "On the Glasgow and Ardrossan Canal, of small dimensions, a spirited horse in the boat of William Houston, Esq., took fright and ran off, dragging the boat with it; and it was then observed to Mr. Houston's astonishment, that the foaming stern surge which used to devastate the banks had ceased, and the vessel was carried on through water comparatively smooth, with a resistance very much diminished. Mr. Houston had the tact to perceive the mercantile value of this fact to the canal company with which he was connected, and devoted himself to introducing on that canal vessels moving with this high velocity. The result of this improvement was so valuable from a mercantile point of view, as to bring, from the conveyance of passengers at high velocity, a large increase of revenue to the canal proprietors. The passengers and luggage were conveyed in light boats about 60 ft. long and 6 ft. wide, made of thin sheet iron, and drawn by a pair of horses. The boat started at a low velocity behind the wave, and at a given signal it was, by a sudden jerk of the horses drawn up on the top of the wave, where it moved with diminished resistance at a rate of about 8 miles per hour." In the above instance, culled from the records of a long past, observation, invention and enterprise led to success. Curiously enough a somewhat parallel case came to the writer's notice recently, and in this case the enterprise of the firm led to the securing of a valuable order. It had been observed that the vessels belonging to a certain company, and plying constantly on an Eastern river created a great wash which caused considerable damage to the banks. Some new craft were required and the owners desired, if possible, that like conditions of speed and carrying powers should be obtained with these as with the other vessels, but that the wave disturbance should be less. Several shipbuilding firms were invited to tender for the new work, and as the result of their enterprise in having long previously established a tank and in making the necessary apparatus for carrying out shallow water experiments, this particular firm secured the order. Their experts developed a form which was much less resistful than that of the ships already on service. Their experiments and observations enabled them to cut down the horse-power almost by half, the pronounced wave effect produced by the older ships was absent from the new form, and economy in running expenses and also in waterway upkeep was secured.

The complaint has been made that there is a lack of careful observation on board ship when reliable data would be of great service to those responsible for the design of hulls and machinery. A naval architect connected with a leading continental shipowning firm told us recently that he could not rely on the figures of power, speed, and coal consumption that were stated in the ships' logs. The tendency prevailed for the engineer to overstate the power developed so as to show a reasonable fuel consumption per horse-power and yet make the coal consumed agree with that actually put on board. This tendency was found to be very misleading, for the firm was enterprising and willing to adopt and experiment with any new invention which promised higher efficiency. But when information was placed before them which was of doubtful accuracy a proper basis of comparison was unavailable. The naval architect referred to warned all the engineers and officers in turn that truthful reports must be given, and that no bias was to be allowed to enter into the figures stated. It is possible to arrive at some important conclusions when observations have been carefully made over a long period, when some definite object has been set and the interest of officers aroused. For example, Mr. Hamilton set about to investigate the effect of fullness in the performances of ships and the voyage records of three particular vessels were carefully analysed. These ships were of the same dimensions but of slightly different blocks, but although under calm water conditions their speeds and powers agreed closely, it was found that average weather conditions at sea affected the fuller vessels to an extent altogether out of proportion to the increase in block. As the result of these observations succeeding vessels were limited in fullness, with no sacrifice in cargo carrying capacity, as the fuel required on the trip took up less space than that used in the fuller ships.

With regard to the behaviour of vessels when pitching or rolling, accurate records are seldom obtained. Take sister ships, for example, it is not uncommon that one vessel has a reputation for steadiness whilst the other has the name of behaving badly at sea. According to all the mathematics in the case there is no reason why one should be steady and the other not. There seems to be strong reasons for assuming that the observations have been faulty. Take the experience with anti-rolling tanks which were invented to afford steadiness in ships. In the published records of the performances of the *Cordova* and *General* which had these fitted the nullifying effect of their action was most pronounced, but no indication was given that, when the waves were not regular in period, their steadying effect was imperceptible. This was noticed in subsequent vessels in which the system was adopted, and in the fleet of liners which have been built since the Armistice this invention has not been adopted. Occasionally the enterprise of owners leads to the wholesale adoption of inventions which have not been sufficiently proved in actual sea experience. It is probably not too much to say that had the troubles associated with double-reduction gearing been anticipated, these would have been less generally applied. The economy promised through greater efficiency of turbines and screws has been met, but unforeseen conditions arose which have caused destruction to the gearing in many cases. But these unfortunate experiences will not deter enterprising owners from venturing in such new directions as the advance in engineering science suggests, although a little more caution may enter into their ventures as the result of past experience.

SELECTION OF THE BEST KIND OF PROPELLING MACHINERY.

IN spite of all that has been written during these past few months on propelling machinery, the selection of the best kind is not an easy task. In November last Mr. Ackerson read a paper to the Society of Naval Architects and Marine Engineers, New York, on the above subject, in which he compared the relative merits of the following types:—(*a*) Geared turbines with Scotch boilers; (*b*) geared turbines with water-tube boilers; (*c*) reciprocating steam engines with Scotch boilers; (*d*) reciprocating steam engines with water-tube boilers; (*e*) Diesel engines, four cycle; (*f*) Diesel engines, two cycle. Then the enterprising North-East Coast Institution of Engineers and Shipbuilders recently issued a uniform ship specification

and a speed-power curve, showing the estimated brake horse-power for a speed of $10\frac{3}{4}$ knots on trial, for a ship of the following dimensions :—Length, 371 ft. ; breadth moulded, 50 ft. 9 in. ; draught, 23 ft. ; displacement, 9,220 tons ; deadweight and carrying capacity, 6,570 tons ; minimum length of engine room, 40 ft. $4\frac{1}{2}$ in. The specification and other particulars were sent to various builders of internal-combustion engines with invitations to give full particulars of their particular type of machinery in respect to the following points :—(1) The total brake horse-power of the engines, stating under what conditions it can be maintained ; (2) the brake horse-power overload obtainable above trial conditions ; (3) the mechanical efficiency of the engine, and the method of arriving at the same ; (4) fuel consumed per brake horse-power when the ship is steaming at the designed speed of $10\frac{3}{4}$ knots ; (5) the type of fuel used and its calorific value ; (6) the total weight of the main propelling engines and auxiliaries in the engine room ; (7) cost per ton mile.

This invitation was ably responded to, and the proposals included these types :—Armstrong-Sulzer, Camellaird-Fullagar, Doxford, Neptune, Scott-Still, Vickers and Werkspoor. The only point missing is the costs of each installation, but these, necessarily, were unavailable. But the types mentioned and compared by Mr. Ackerson, together with those brought before the North-East Coast Institution, do not complete the list. On February 7 Mr. R. S. Johnson read a valuable paper to the Liverpool Engineering Society on "Electric Propulsion of Ships." In it he drew some comparisons between these types for the same vessel :—Triple-expansion, single-screw ; turbo-electric, single-screw ; oil engines with electrically-driven auxiliaries, twin-screw ; Diesel electric-drive, motor aft, single-screw. The addition of the electric type of machinery even does not complete the list, but a sufficient number of types have been mentioned to indicate the almost impossible task which confronts one who essays to choose the best. The whole question boils down to one of commercial utility. It may be taken for granted that reliability can now be guaranteed for each particular type of engine. On this score it has been said that if internal-combustion engines are being adopted, that particular type which has the longest record should be chosen. This may be rather an unenterprising way of viewing the problem, for it is quite possible that types which have more lately been evolved possess advantage which those first in the field do not. Viewed from the standpoint of practical application and proved reliability it is possible that, of Diesel machinery, Burmeister & Wain's four-cycle type has the best record. The large number of vessels built for the East Asiatic Company, and fitted with Burmeister & Wain's engines, demonstrates the fact that for their particular trade the type has been highly successful. In a similar way their allied British company have had many successes, Harland & Wolff Limited having installed oil engines in many vessels, particularly for the Glen Line, which have given entire satisfaction.

Although these engines have probably the longest record of sucess it would be unwise of owners to leave out of consideration the claims of more recently developed types. Owing to the pressure of work during the war period certain builders found it impossible to devote the time to developing the oil engine as they had other types. Now that the internal-combustion engine has come into general practice these builders are making experimental sets which may well be more economical and as reliable as those already established. Whilst the pioneers in oil-engine development had much to learn through rough experience, those firms now entering the lists have the benefits of these experiences to guide them. One can therefore anticipate that firms which have made themselves famous as builders of other types of marine engines will be equally successful in oil-engine construction. Accepting, then, the probability of equal reliability in each type, the questions of initial cost, weight, fuel consumption, complement, cargo capacity and of running expenses, call for consideration. In the case of the cargo ship for which the North-East Coast Institution invited "competitive tenders," the cost of a reciprocating set of machinery of equivalent power, coal burning and with Scotch boilers, would be in the region of £30,000. It is probable that the average cost of the proposals put forward for internal-combustion engines would be around £55,000. An allowance of 15 per cent. per annum must be assumed for depreciation, repairs and various charges, therefore the oil-engined vessel would require to earn an additional £3,750 per annum to equal the steamer. Assuming 200 days' steaming, this means an economy, or else greater earning power, of £18 15s. per day. On the average, 9 tons of oil at 80s. per ton would be consumed on the one hand against about 27 tons of coal at, say, 40s. on the other, or £36 per day for fuel in the oil ship against £54 on the steamship. From the point of view of cost of fuel the economy about balances the additional charges to be met. It appears, therefore, that all additional cargo space available through less weight of fuel being required, and through actual gain in capacity, means direct profit. The amount of this profit becomes greater the longer the voyage, as Mr. Ackerson's figures clearly shows. A reduction in the number of the crew also accompanies the adoption of the oil engine, and this is also added to the credit side to counteract the greater additional cost. In spite of these undoubted economies it is possible that for ships engaged in short runs the advantages of the vessel with reciprocating engines and coal-fired boilers are greater than those of oil-engined vessels, and the days of the former may not yet be numbered.

A strong case has been made out for electrically-propelled ships, and in the States this system has been adopted with marked success. Its sphere of usefulness is much wider than that of the internal-combustion engine, and in high-powered vessels its only rival is the geared turbine. Mr. Johnson gave some interesting comparisons of the economics of this type compared with others in the paper referred to above, and his figures should be the more closely studied because his firm have developed the Camellaird-Fullagar oil engine, besides having produced many high-powered geared-turbine ships. The trials of the elecrically-propelled ships will be awaited with interest, and doubtless the anticipations of success will be fulfilled. Altogether the problem of the choice of the best type of propelling machinery is a difficult one to solve. In a few years time more definite information may be available on which to form a judgment ; in the meantime the usual enterprise of owners must assert itself so that each of the available types may be tried, and experience ultimately prove the claims which are so definitely made for each.

ENGAGEMENTS FOR APRIL.

Institution of Engineers and Shipbuilders in Scotland.—Meeting in the Rankine Hall, 39, Elmbank Crescent, Glasgow, on Tuesday, April 10, at 7.30 p.m.

Institute of Marine Engineers.—Annual meeting at the Institute, the Minories, Tower Hill, London, E., on Friday, April 6, at 6 p.m. On Tuesday, April 17, "The Operation of Water-tube Boilers for Cargo and Passenger Ships," by R. Clark.

North-East Coast Institution of Engineers and Shipbuilders.—Meeting in Lecture Theatre, Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne, on Friday, April 6, at 7.30 p.m., "Powdered Coal as Fuel," by Dr. J. T. Dunn.

Institution of Mechanical Engineers.—Meeting at the Institution, Storey's Gate, St. James's Park, London, S.W., on Friday, April 20, at 6 p.m.—*Midland Branch.* Meeting in Birmingham University, Edmund Street, on Thursday, April 26, at 7.30 p.m. "Epicyclic Gears," by F. W. Lanchester, LL.D., F.R.S. (member of Council), and G. H. Lanchester.

Liverpool Engineering Society.—Meeting at the Royal Institution, Colquitt Street, on Wednesday, April 4, at 8 p.m. "The Combustion of Fuel," by Prof. G. E. Scholes, M.Sc. (Vict.), and "Consideration in Design and Application of Surface Heaters," by B. Stephenson.

BOOKS FOR THE MARINE ENGINEER AND NAVAL ARCHITECT.

Brief Reviews of Recent Publications.

A Text-book on Heat and Heat Engines. By Andrew Jamieson, M.Inst.C.E. Vol. II. London: Charles Griffin & Co. Limited, Exeter Street, Strand, W.C.2. 428 pp. Price 8s. 6d. net. Numerous diagrams and folding plates.

This book, now in its eighteenth edition, has been re-written and revised by Mr. Ewart S. Andrews, B.Sc., and it "completes the extension of the late Prof. Jamieson's Advanced Text-book on 'Steam and Steam Engines' to cover 'Heat and Heat Engines.'" To engineers the book needs no introduction, but we feel that there are many points in connection therewith worth mentioning. Marine engineers of course will appreciate the sections dealing with marine engines. The historical chapter is exceptionally compact, and we feel that this is a useful point. In any volume dealing with the varied branches of applied science, an historical résumé of the section under discussion is of great value to the student, but the skill of an author is shown in his selection of how much to put in and how much to omit. Professor Jameson exercised a nice discretion in this matter in his original edition, but we feel that, coming to the modern side of the question, in the subsequent editions, the marine engine data should have been considerably modernised; for instance in the "Table of the Chief Measurements of Recent Atlantic Liners," on page 286, the most "recent" liner described in the table is the *Kaiser Wilhelm II*, of 1902.

Nickel. By F. B. Howard White, B.A. London: Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, W.C.2. Pitman's Common Commodities and Industries Series: 118 pages. $7\frac{1}{2}$ in. $\times$ 5 in. $\times$ $\frac{3}{8}$ in. Price 3s. net.

This is a useful little handbook which deals with a metal about which comparatively little is known, as the author states. In the small space at his disposal the author has dealt with the subject in a remarkably concise form, and the following are some of the most interesting points he emphasises:—The widespread use of three-electrode ionic valves (Fig. 14) has demanded the production of particularly pure malleable nickel for these instruments (page 52) and the present wireless broadcasting boom will occasion a large increase in the number of amplifier valves manufactured. The use of nickel steel for long span bridge construction is of considerable interest to engineers (pages 80-82). As a toughening element for steel, large quantities of nickel will be used in the armament of the two new 35,000-ton battleships, *Nelson* and *Rodney* (pages 86-90). The facts concerning the refining of nickel are but little known by the metal trade, and the explanations and illustrations of the types of refined nickel now obtained commercially (pages 20-2) should certainly be of use to those outside the nickel industry who have occasion to deal with this metal.

"The Journal of the Institute of Metals." Volume xxviii. Edited by G. Shaw Scott, M.Sc. London: The Institute of Metals, 36-38, Victoria Street, S.W.1. 1010 $\times$ ix pages. XXXVII. Plates and numerous figures in the text. Price 31s. 6d. net.

The Journal of the Institute of Metals has now become a substantial volume, and the latest issue covers over a thousand pages, this being several hundred pages more than any previous volume. The increase in size appears to be due to three causes:—firstly, to the large number of papers contained in Section I—which consists of the official minutes of Proceedings of the Institute and covers 500 pages; secondly, to the greatly enlarged Section II, which embodies over 400 pages of abstracts of metallurgical and allied papers published throughout the world; and thirdly, to the very full index which contains over 5,000 entries. The papers reproduced in the volume are 17 in number, and they deal with a large number of metals and alloys. They include not only all those that were presented at the recent Swansea meeting of the Institute, but also Sir Ernest Rutherford's May lecture on "The Relation of the Elements," and Dr. R. S. Hutton's autumn lecture on "The Science of Human Effort" (Motion Study and Vocational Training). There are also verbatim reports of the discussions on the various papers, and the communications upon them received since the papers were presented. The detailed list of many hundreds of the world's metallurgical and allied periodicals we feel should be valuable for reference purposes. The publisher's name and address of each of these periodicals is given, together with the price and date of publication.

Dock Engineering. By Brysson Cunningham, D.Sc. London: Chas. Griffin & Co. Limited, Exeter Street, Strand. W.C. 6 in. $\times$ 9 in. $\times$ $2\frac{1}{4}$ in. 600 pp. Numerous diagrams and folding plates. Price 42s. net.

This volume, one of the standard reference works on the subject, appears now in its third edition. We feel that neither the book nor the author need any introduction, since both are well known to engineers of all denominations, although possibly more especially to those whose work has connection with docks and harbours. The third edition has been thoroughly revised, and embodies much that is new. An abstract of the latest British standard specification for Portland cement has been embodied in the appendix, which also contains other useful notes.

Merchant Ships of the World. By Frank C. Bowen and F. J. N. Wedge. London: Sampson, Low, Marston & Co. Limited, 100, Southwark Street, E. $12\frac{1}{2}$ in. $\times$ $10\frac{1}{2}$ in. $\times$ $1\frac{1}{2}$ in. 442 + 34 pp. Illustrated. Price £3 3s. net.

Here is a volume which we thoroughly recommend to the consideration of all those in any way interested in shipping. It is published by the house which publishes the well-known sister annual dealing with Fleets of the world, and, incidentally, it has the advantage over this latter, from a utility point of view, of being considerably more shapely to handle. Ships are classified under their respective owners; and information is given as to tonnage, deadweight, number of hatches and machinery. There is also a column giving the rise of floor of the various ships, which will be appreciated by those who have anything to do with docking. The authors must have found it a difficult task, with so much potential information at hand, to discriminate and decide as to which was the best to include in the lists of information, and we feel that they have chosen quite wisely. There is also a very useful section dealing with the identification of merchant ships, and grouping them under their various characteristics.

TRADE PUBLICATIONS.

The Brush Electrical Engineering Company Limited, Loughborough, have issued a descriptive illustrated booklet dealing with their Liquid Starters.

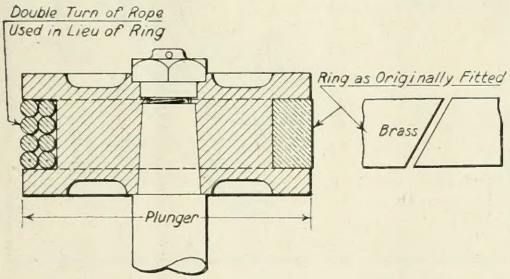
EMERGENCY ENGINEERING ABROAD.

Some further Accounts of Quick Repair Work carried out in the Near East.

We continue this month accounts of emergency repair work to fleet auxiliaries carried out by H.M. light cruiser *Centaur*, when acting as evacuation vessel at Chanak last year. In our last issue we described a motor boat repair, repairs to a winch, and methods of determining the pitch for new propellers. This month we continue with :—

An Air-Pump Repair.

A tug reported that her air pump was non-operative, and that she could not proceed. The pump was opened out and it was found that the solid brass packing ring had fractured, and scored the ring recess. As there was no material on board the cruiser from which a new ring could be made, the old ring was removed, and the surfaces of plunger filed up. Some very hard rope was then obtained (six-strand tarred rope was used), a stop was fitted in the body of plunger and one end of the rope

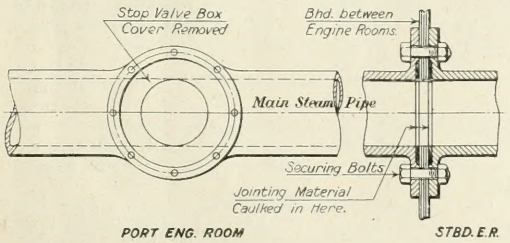


Air Pump Packing Ring Extemporised from Rope.

bound to prevent flaying. The rope was then wound tightly round the body of plunger in the recess before occupied by the ring. It was found that a double turn would fill the recess, with enough projecting to ensure a good fit in pump barrel. The rope was then bound at outer end, a slip fitted and the plunger replaced.

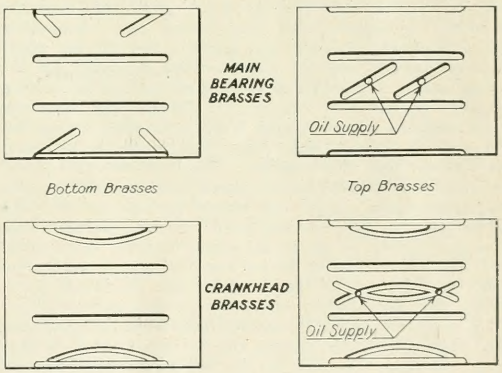
Temporary Repair to Leaky Joints.

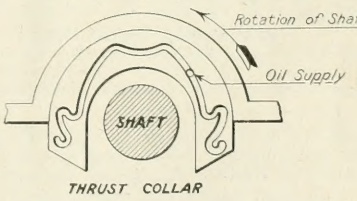
A small twin-screw reciprocating engined vessel was fitted with a watertight bulkhead between the two engine rooms. Through this bulkhead the main steam pipe passed, the shut-off valve being on the port side, adjacent to the bulkhead, as will be seen in the diagram.



Method of Temporarily Repairing Leaky Steam Pipe Joint.

The joints on either side of the bulkhead leaked badly, and had it been necessary to dismantle the main run of steam piping, it would have entailed a considerable amount of work in disconnecting and connecting up pipes ; the ship, of course, being out of action for this period. As it was not practicable to put the ship out of action for so long, and the loss of steam (water) due to the leak was very considerable, the following method of temporarily stopping the leak was adopted. A mixture of belleville cement (well mixed red lead would have served the same purpose) and fine spun yarn was made, and a number of steel wedges were made with very fine knife edges. The stop-valve cover was removed, and, with a wandering electric lead, it was just possible to see and reach the inside portion of the steam pipe where the port and starboard sections were secured to the midline bulkhead. The junction of the three was well cleaned, the jointing mixture forced in all round the joint (as shown in diagram). This was caulked in by the knife-edged wedges. The process was repeated a second time, and the whole allowed to dry. All drains on the main line of steam piping were opened and the pipes thoroughly drained, the stop-valve cover being left off until all the moisture had evaporated. The cover was then replaced and dry steam admitted for six hours in order to dry the cement. When steam was required, extra precautions were taken when lighting up and warming through, and the repair proved quite steam-tight when the engines were running at full speed. The H.P. receiver pressure was 150 lb. per sq. in. ; and there were no further signs of leakage after a month's constant running.





Sketch showing Method of Cutting Oilways.

Oilways in Bearings.

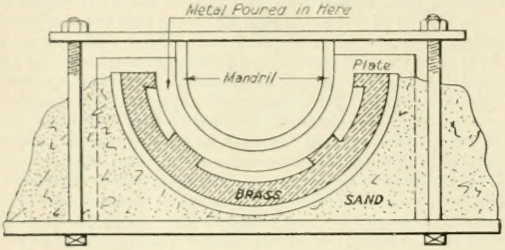
In many cases reciprocating engined craft reported that the main bearing and crank-head brasses were running hot,

also the thrusts, and that full speed could not be maintained. In a few cases the vessels were brought alongside the cruiser which was doing the repairs, and the bearings were opened up and examined. In practically all cases the oilways were found either splayed over with metal, or incorrectly cut. In the former case the oilways were cleaned and the brasses scraped up. In the latter case, a standard method of cutting was adopted, and the diagrams clearly indicate this method. In some cases it was found necessary to refill the incorrectly cut channels with white metal.

In the thrust-collar oilways it will be noticed that the channels are cut so as to form pockets for the lubricating oil.

Re-metalling Brasses.

The appliances for remetalling were necessarily crude, but the results were quite satisfactory, the method adopted being as follows:—A circular mandril was bent into



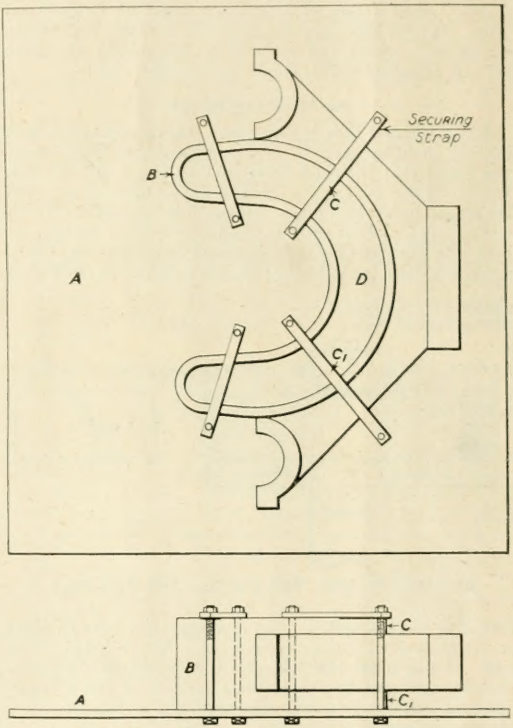
Sketch showing Method Adopted for Re-metalling Brasses.

required radius, *i.e.*, such as would give the necessary thickness of white metal after boring out. Supporting pieces were cut to carry the mandril, and the flat plates bearing against ends of brass formed a mould for the white metal. The old metal was first cleaned out by melting, and the recesses were cleaned and tinned. The brass was next heated, a circular motion being maintained during this operation in order to ensure even heating until the tin would melt at any part of the surface. The brass was next placed on a slab or floor plate, and the mandril and supporting plates whitewashed and heated and secured in position. In order to keep the brass hot, sand was packed round it. Sal ammoniac was next thrown on the tinned surface and the metal ladled in. The white metal at the top was kept hot by red-hot fire bars until the body of the metal had set. Shrinkage necessarily took place, and to compensate for this, more metal had to be added, and in order to ensure a good sound job great care had to be taken in the tinning, and the mould had to be kept clean and dry. The film of tin was molten when pouring in the white metal, and the feeding had to be done very carefully. Should the metal be overheated it cracks, so it was necessary to keep the whole of the surface at a uniform temperature.

Re-metalling Thrust Collars.

This thrust collar was of the familiar horse-shoe pattern. The old metal was first melted out and the collar carefully tinned, which is of the utmost importance in remetalling thrust collars. When tinned the collar was aranged in a core, as shown in the diagram.

The core consisted of a flat-bottom plate A and a bent vertical plate B, which followed the contour of the horns of the collar. Two strips, c and c_1, were bolted to the plate A, the whole then forming a complete mould for the metal, the thickness of metal required being arranged for. When the parts were



Sketch showing Method of Re-metalling Thrust Collars.

properly assembled and the oil passages in collar blanketed with asbestos, the collar was heated to the same temperature as the molten metal and placed in the core. The whole was then firmly secured by bolts and straps and slightly inclined, the horns being highest. The metal was poured in at D, the accumulated bubbles of air leaving at highest point, *i.e.*, the horns of collars. The whole was surrounded by sand to keep the collar warm and allow it to cool slowly.

Handling of Carbide of Calcium.—The attention of owners and skippers of vessels using acetylene is called by the Board of Trade to two serious accidents which have occurred in recent years on such vessels: namely, on the steam trawlers *King Harald* (in 1917) and *Betty Johnson* (in 1922). In the former case three men were killed, three se-erely injured, and the vessel had to be beached in a sinking condition. In the latter case one man was killed, three were severely injured, and considerable damage was done to the vessel. Owners, skippers, and all concerned with preparing ships for sea are reminded that they are bound to see that their ships are sent to sea in a safe condition, and that all reasonable and proper precautions are taken to prevent accidents of the kind described above.

One precaution which should in no case be omitted is to see that drums of carbide of calcium are lowered into the engine room and stowed in a safe place before the engines are started. It is most important that all persons concerned should take the necessary measures to secure that in practice at least this precaution is not neglected.

THE INFLUENCE OF TEMPERATURE ON THE STRENGTH OF MATERIAL.

The Higher Working Temperature of the Modern Prime Mover—Metallurgy and The Internal-Combustion Turbine.

Very considerable progress has been made during recent years on the twin subjects of the treatment of metals with the object of enabling them to withstand much higher temperatures than those with which their use has hitherto been associated, and also in the production of improved steel alloys as well as more suitable composition of non-ferrous alloys, which, apart from any heat treatment, will render them far better able to resist the action of intense heat and to retain their elastic and tensile strengths to a greater extent than has hitherto been the case. The matter has a very special bearing on the prospects of the internal-combustion turbine in particular, the advent of which is at present very largely frustrated by the difficulties due to continuous application of high temperatures, and by the deterioration of metal and the serious if not prohibitive, reduction of strength which occurs in their presence. The literature on the subject is by no means profound, though some exceedingly useful pamphlets have been issued by both British and United States authorities, dealing with various phases of a question that is of growing importance at the present time.

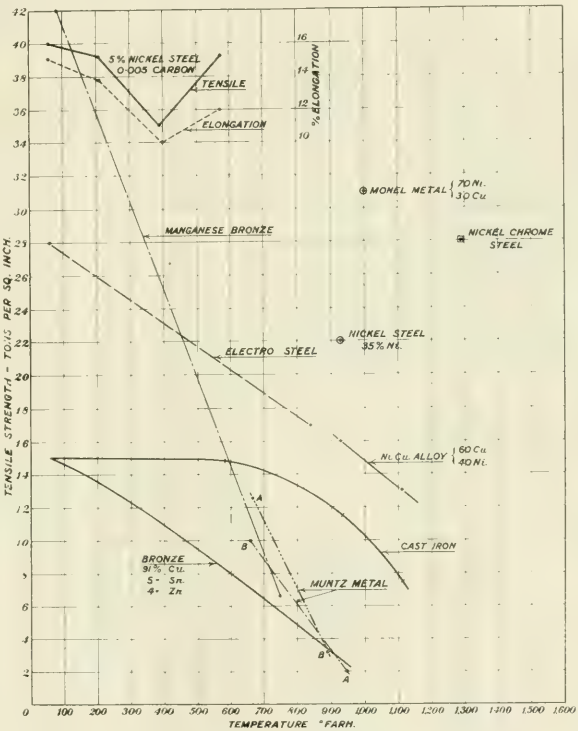


Chart showing the Temperature effect on the Tensile Strength of Certain Metals.

Volumetric Growth of Cast-Iron under Heat Treatment.

The very appreciable volumetric growth of cast-iron when subjected for long periods to a temperature of even 500°-550° Fahr. has been known for many years, and during the course of the development of the reaction steam turbine, with its fine clearances, this effect often gave rise to minor difficulties, which were at first attributed more to the temperature than to the alteration of the structure of the metal itself, as it was eventually proved to be, and it is precisely this form of influence that is to be found in the case of material working under highly stressed conditions, involving motion compared with the stationary functions of, for instance, cylinders and liners. While experience with the temperatures encountered in the internal-combustion engine is growing very rapidly at the present time, and is enforcing more and more attention being paid to the precise constitution of iron and steel for the cylinders and moving parts, it is not generally realised what a very considerable change has taken place in the conditions under which the principal portions of prime movers have now to operate, simply on account of this element of increase of temperature.

Until comparatively recently, the very highest temperatures used in steam engineering, as regards the main engines (*not* the boilers), were not sufficient to affect to any serious extent any of the metals generally employed, though the abandonment of brass or gunmetal castings, or of copper piping has been going on for many years. When superheat is not adopted they are often retained, but the continual advance in temperature for reasons of thermal efficiency in the case of steam, has gradually been effecting considerable change in the nature of the materials of construction adopted. Except for a handrail or a gauge-glass frame, one can often look in vain nowadays for non-ferrous metals, and the consequent change in the appearance due to the alteration in the colour of machinery—a fact often passed over quite unnoticed — is sometimes very marked.

Increase of Working Temperatures.

Within the last few years, however, even steam temperatures have been creeping up without, attracting very much attention, and it is somewhat apparent that research as to physical properties of metals under these and even more intensive conditions has hardly been keeping pace with the development in temperature. A further fact which aggravates considerably the weakening effect of temperatures on metal strength is the simultaneous increase in working pressures often adopted. Many large power stations are using 325, 350, and even 400 lb. steam pressure, and the highest total steam temperatures now experienced in land practice are approaching 750° Fahr. at the turbine. In marine work, where the cylindrical boiler practically limits the pressure to about 215 lbs., temperatures exceeding 500° Fahr. (= 110° Superheat) at the turbine are rare.

Even the upper limit in steam practice is, if anything, considerably below the exhaust gas temperature of a big marine oil engine, while the maximum temperatures experienced for fractional periods of time during the intermittent explosions exceed the melting points of iron and steel, and would be quite impossible were the period of application to

to be considerably increased. In the case of the internal-combustion turbine this fact often involves a large number of cylinder chambers working in succession on a constant-volume cycle, as in the German Holzwarth oil combustion turbine, or else a considerably increased excess air factor—a reduced mixture strength, in other words—until such time as materials capable of withstanding continuous high temperatures are available.

Production of Non-ferrous Alloys.

It is the search for these for many other purposes, however, besides those of gas turbines, which has resulted in the production of various ferrous and non-ferrous alloys which possess excellent physical properties under fairly high temperatures. Extensive results of their constitution and, simultaneously, of their elastic and tensile qualities are not available, except in somewhat widely separated form, and though a number of isolated figures are available to indicate the particular influence on material strength of temperature, it is only rarely that these are given for really high temperatures—say above 1,000° Fahr. The attached chart, compiled from a number of figures published by the Directorate of Research of the Air Ministry some time ago, gives a few results which serve to illustrate the general tendency of temperature effect on tensile strength for certain metals. Data for temperatures exceeding 1,600° Fahr. is very scarce; it is scantier still when ultimate strengths of more than 20 tons per square inch under such conditions are involved. But the data is of interest in that it shows both the nature of the influence for different materials, the lack of data on the subject, the nature of the direction in which progress may be made and the need of further research at the higher temperatures.

Bronzes and Muntz Metals.

The most marked feature of the diagram is the very rapid drop in strength of the bronzes and Muntz metals, which became altogether unsuitable for temperatures exceeding about 600° Fahr. Up to this point, good cast-iron is hardly affected as far as strength is concerned, though it alters in structure with continued subjection to such a figure. Above 700° Fahr. it begins to fall off rapidly and at 1,100° Fahr., or somewhere in the neighbourhood of the mean temperature in the cylinder of a two-stroke engine, the strength is only half that of the cold value. An extension of the curve for cast-iron to 1,600° or so would have been interesting in view of the fact that this is still only about 60 per cent. of its melting point. The bronzes, of course, were not designed to withstand high temperatures, and copper itself melts at about 2,000°, but, as shown by experience with large oil engine cylinders, the addition to cast-iron of small quantities of aluminium, magnesium and of iron silicates is beneficial. This is the composition of the sample of which the last curve is given.

In steam practice, a 5 per cent. nickel steel containing less than one-half of one per cent. of carbon has been extensively employed for both discs and blading, with good results. A typical test curve of this material is shown in the top left-hand corner of the chart.

The influence of nickel percentage is variable; above 5 per cent. the efficiency first deteriorates, but with as much as 35 per cent. a figure of 22 tons per square inch tensile at between 900°-1,000° Fahr. has been recorded. The addition of chromium, tungsten, or vanadium, also has a very beneficial effect on the heat resisting qualities of steel, always provided that the carbon content is very small. The highest strength at the highest temperature recorded on the chart, viz., 28 tons at 1,300° Fahr. was obtained with a nickel chromium steel, but further experience is necessary before it can be said that these composite nickel steels are thoroughly reliable. Tungsten steel has been used in the little exhaust-gas turbines employed in the Royal Air Force for driving small blowers for supplying air under pressure to petrol engine carburettors at high altitudes. The rotor wheels made of this material are very small, being only a few inches in diameter, but the blade speed at which they work in a temperature of about 1,200° Fahr. considerably exceeds 800 ft. per second. Holzwarth, in a description of his gas turbine tests has stated that he used an electro-steel with a yield point of 13 tons and a breaking strain of 17 tons at a temperature of between 800-900° Fahr., the strengths at 60° Fahr. being 23 and 28 respectively. 'Electro-steels are characterised by the extremely low carbon contact while phosphorus and sulphur are practically absent. The straight line connecting these results of Holzwarth's, which are taken from the latter's paper in the *Zeitschrift des Vereines Deutscher Ingenieure*, in February, 1920, probably does not credit this material with adequate strength at the lower range of temperature, it is more than likely that the true form approximates to that of the first part of the curve for the 5 per cent. nickel steel.

"Peripheral" Stresses in Blades.

The difficulty which, in this case of the internal-combustion turbine, is so greatly accentuated by the reduction in strength, due to temperature, lies in the fact that very high peripheral blade speeds are necessary. These set up very high stresses —stresses, in fact, which are far above those permissible with a drum type of rotor, and which, even with most suitable design of disc which can be evolved, run up to over 10 tons per square inch at speed of 1,000 ft. per second. With the 35 per cent. nickel steel in a medium of 900° Fahr. this stress is so high that the factor of safety would be reduced to only 2·0, and a factor of even 3·0 on the ultimate strength is only obtainable by reducing the blade speed to 820 ft. per second. Even this is considerably above what is generally accepted in large stationary turbines, but in their case it is commercially undesirable to run so fast as it involves very heavy bosses for the turbine discs and these entail a very much heavier and longer turbine. The use of non-ferrous alloys is, of course, an extremely costly matter if they are extensively employed, but many have given very good results. Nickel-chrome, however, is not an easy metal to work. The well-known Monel metal contains about 70 per cent. nickel and 30 per cent. copper and is stated to have a tensile strength of 31 tons per square inch at 1,000° Fahr. It is difficult to work, and the addition of chromium, although increasing the strength renders it even more so, though this has been remedied by the addition of a small percentage of silver. Work on these alloys is progressing and there is no doubt that as far as strength only is concerned the temperature limits can be raised considerably for the same elastic and tensile strength.

Rapid Temperature Changes.

These, however, are not the only factors to be taken into account. For practical purposes, materials capable of withstanding the high temperatures quoted above must also stand rapid changes of temperature, such as those incurred in starting up or cooling down, without undue internal strains; they must be capable of being accurately worked, and they must not be corrodible by the working substance. Very great advances in the production of rustless steel blading for steel turbines have recently been made, particularly by Messrs. Thomas Firth & Company, of Sheffield, but again, this blading has only to withstand comparatively low temperatures at most, and at the point where the rust-resisting quality is most essential the temperature of the steam is below 212° Fahr. It is the erosive effect of a high velocity jet of gas on a blade heated to between 900°-1,000° Fahr. which still remains to be determined. Holzwarth states that his blades made of electro-steel, have withstood temperatures up to 940° Fahr. without difficulty, and a process of heating the blades should advance this

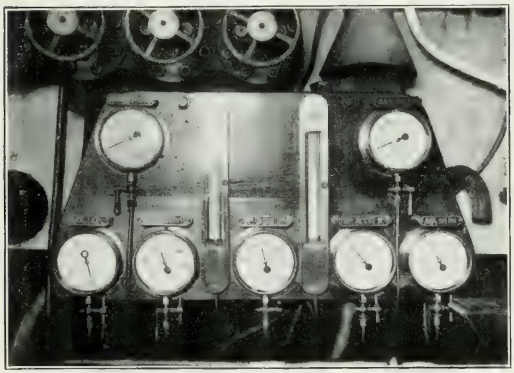
(*Continued on page* 137.)

MODERN MACHINERY SPACES—III.

The Commonwealth and Dominion Refrigerated Liner "Port Hardy," built and engined by R. & W. Hawthorn, Leslie & Co. Limited, Newcastle-on-Tyne.

We are dealing this month with the main, auxiliary and refrigerating machinery of the Commonwealth and Dominion Liner *Port Hardy*. The vessel is a new one, and both hull and main propelling machinery have been constructed by R. & W. Hawthorn, Leslie & Co. Limited, Newcastle-on-Tyne; she has been designed for the Australian meat trade and left the Thames on her maiden voyage on March 6. The following are her leading particulars :—

Hull.	
Length b.p.	481·2 ft.
Breadth, moulded	62·3 ft.
Depth, moulded	33 ft.
Tonnage.	
Deadweight	11,300 tons.
Gross register tonnage	8,705 tons.
Net register tonnage	7,776 tons.
Engines.	
Number and type	Two sets triple-expansion reciprocating engines.
Horse-power	4,500 i.h.p.
Boilers.	
Number	Four.
Type	Scotch.
Fuel	Coal.
Draught	Howden forced.
Superheat, deg. Fahr.	200 deg.
Working pressure	200 lbs. per sq. in.



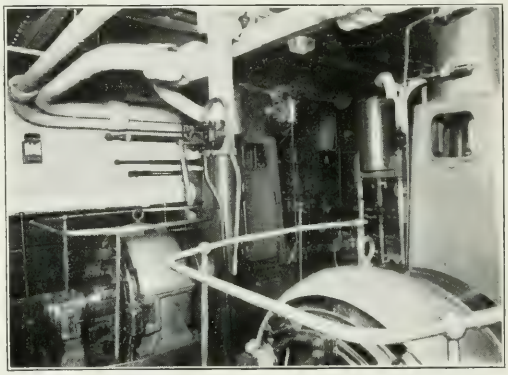
Photograph showing Gauges and Thermometers for registering Superheat.

General Particulars.

Constructed with a straight stem and cruiser stern, the vessel is of the three-deck shelter deck type. Five holds are arranged with large hatches and clear spaces suitable for cargo of a bulky nature, such as machinery and Colonial plant. The vessel has eight watertight bulkheads, 17 derricks of 7 to 10 tons, and one of 35 tons lifting capacity, and 15 steam winches are fitted for the ready handling of cargoes.

Nos. 1, 2 and 4 holds and main 'tween decks are insulated for the carriage of frozen meat, the refrigerating machinery being placed abaft the engine casing with the necessary insulated store rooms immediately underneath.

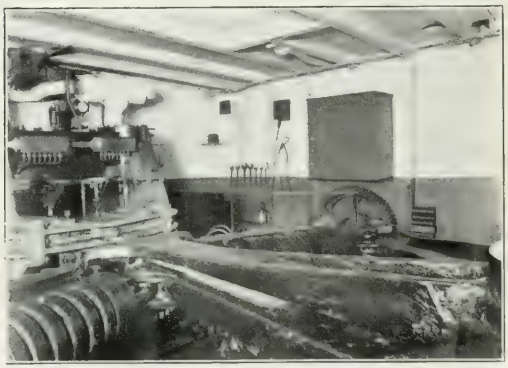
Accommodation is provided for first-class passengers in deckhouses on the shelter deck amidships, with large saloon, pantry and stores. There is also provisional accommodation for about 650 emigrants in the Shelter 'Tween Decks. Deckhouses are provided for entrances and lavatory accommodation.



Photograph showing Main Generators at Aft End of Machinery Space.

Main Propelling Machinery.

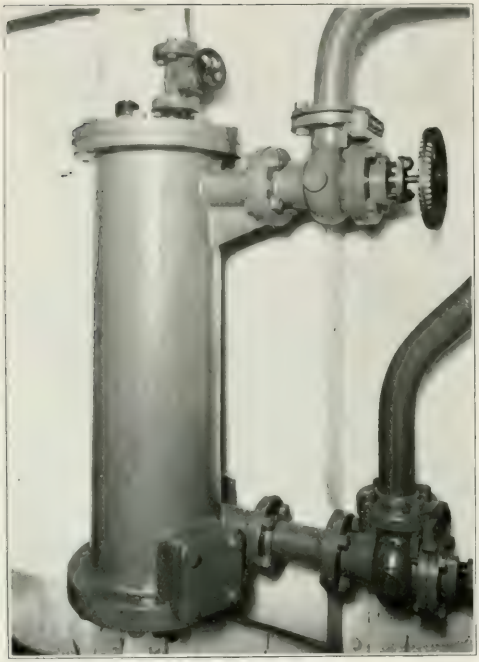
At a time when the geared turbine has had a run of popularity, and when the internal-combustion engine has made such rapid strides towards popularity, besides occupying the closest attention of all far-seeing engineers, it is of interest



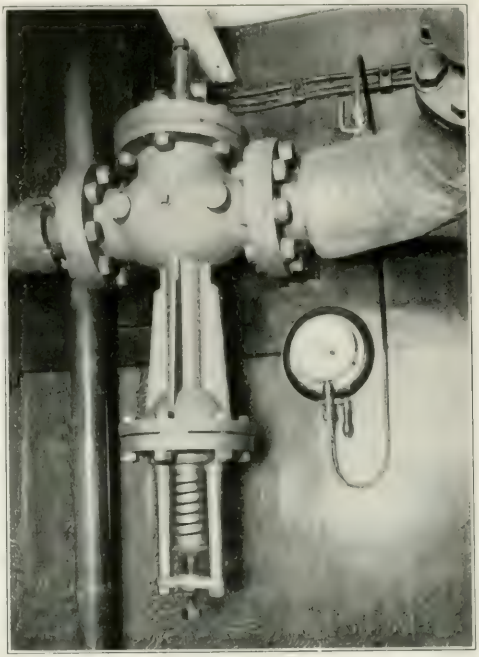
Steam Steering Engine, Tiller, and Spring Shock Absorbers.

to find a new vessel fitted with reciprocating engines. The reciprocating engine has given sterling satisfaction in the past and its present performances are known quantities, and owners who arrange for their tonnage to be propelled by such machinery can be sure of absolute reliability. Such evidently was the opinion of the owners of the *Port Hardy*, for the vessel is fitted with twin screw triple-expansion machinery

SOME VIEWS OF THE AUXILIARIES OF THE

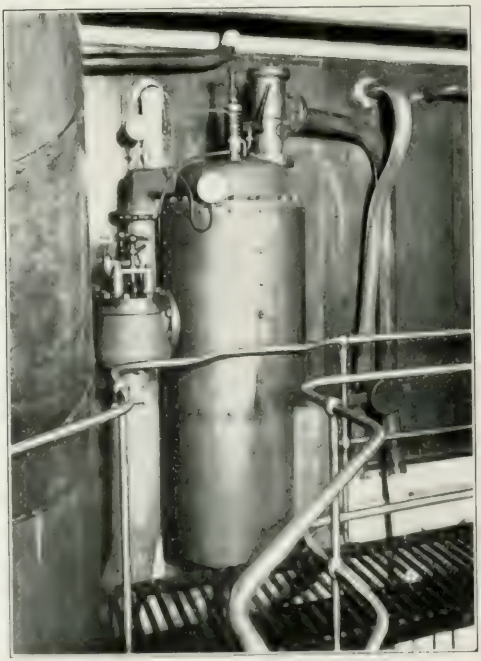


Heating Coil in Refrigerating Engine Room for "Thawing Out."



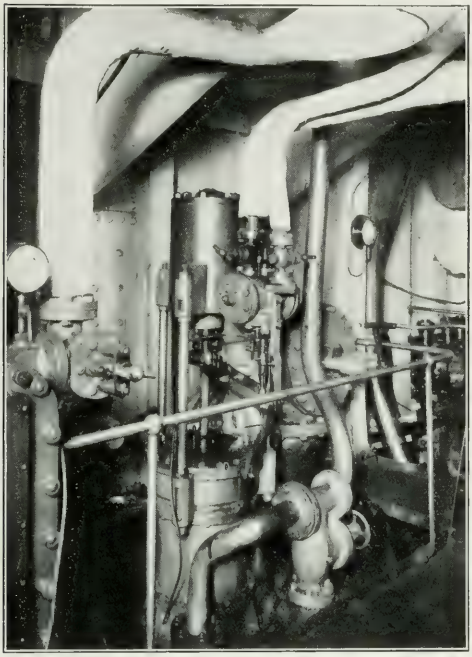
Auld Valve for Reducing Steam Pressure to Refrigerating Engines.

High-Speed Reciprocating Engine for Auxiliary Circulating Pump.

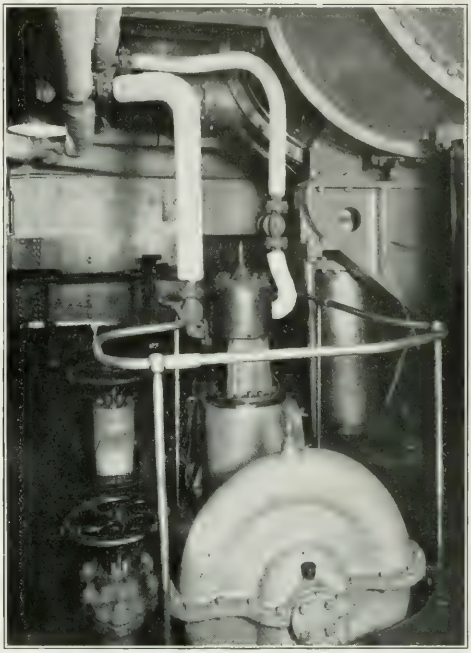


Weir's Direct Contact Feed-Water Heater.

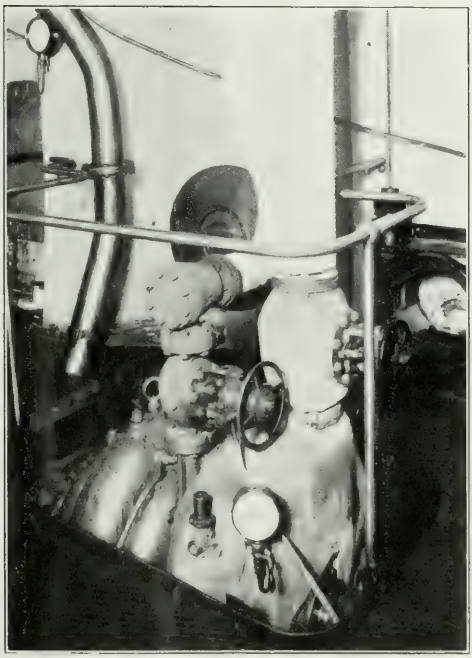
COMMONWEALTH AND DOMINION LINER "PORT HARDY."



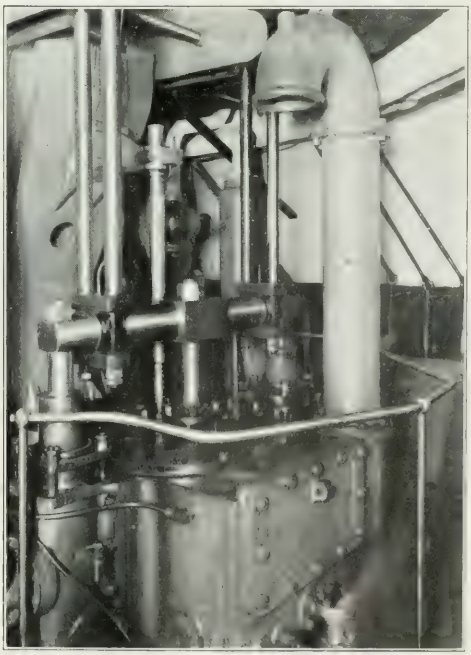
Auxiliary Feed Pump situated at Boiler-Room Bulkhead.



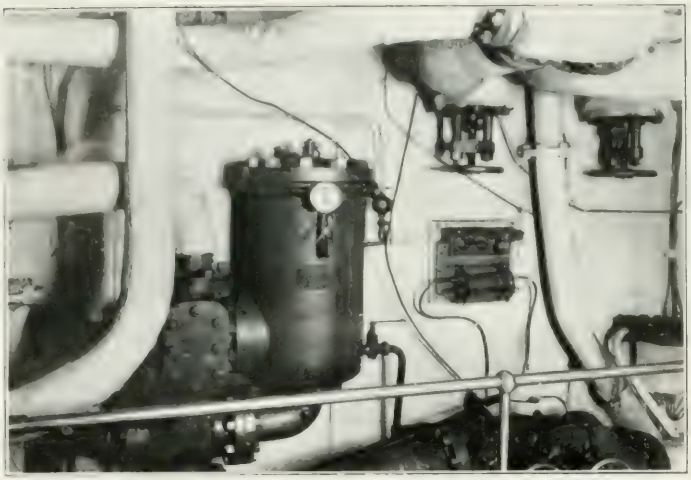
Auxiliary Circulating Pump on Port Side of Engine Room.



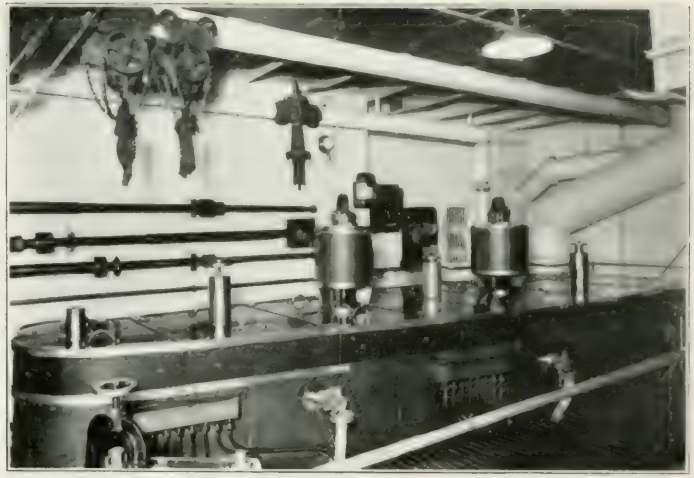
Main Turbo-driven Circulating Pump.



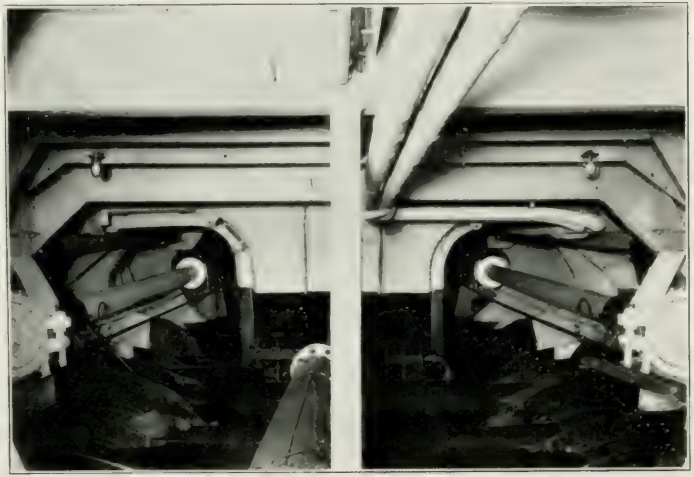
Main Air Pump, showing Beam-Drive from Main Engines.



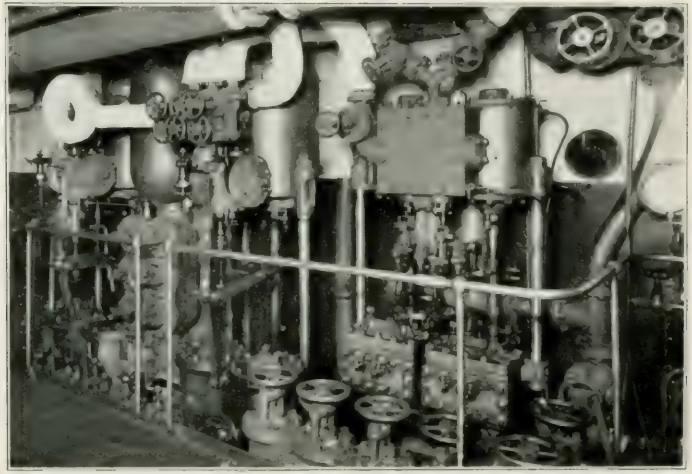
Edmiston Feed Filter and Cumberland Electrolytic System on Boiler-Room Bulkhead.



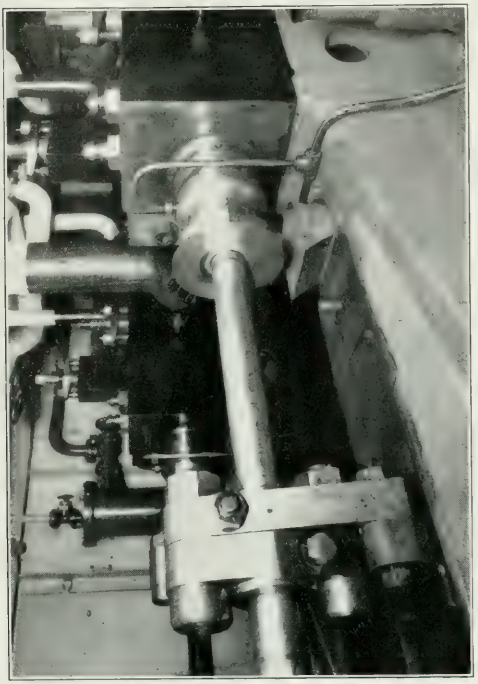
Photograph showing the Cylinder Tops of the Starboard Engine. Door to Engineers' Workshop in Background.



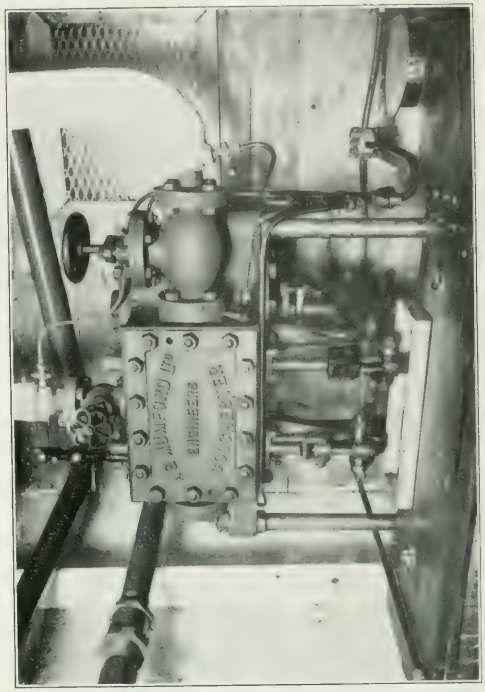
View of Flat at Aft End of Shaft Tunnels, showing Spare Tail Shaft.



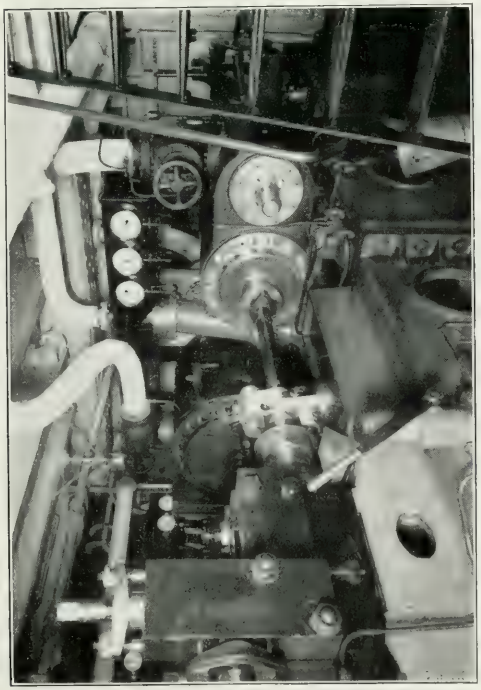
Main Feed Pumps at Boiler-Room Bulkhead.



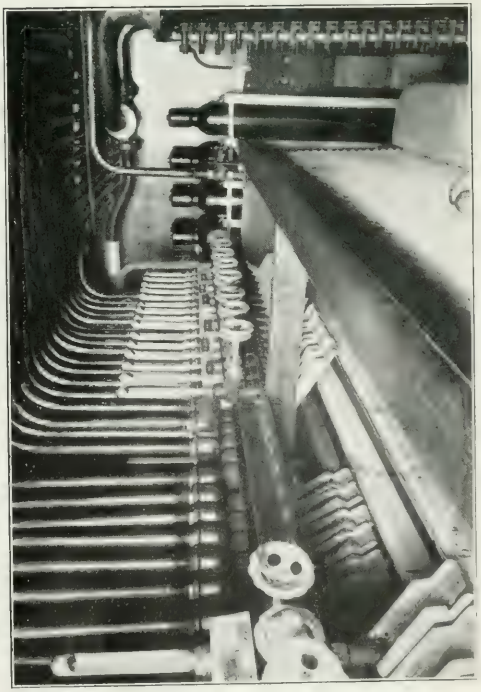
Main Compressor of one of the two CO_2 Machines.



One of the Brine Circulating Pumps.

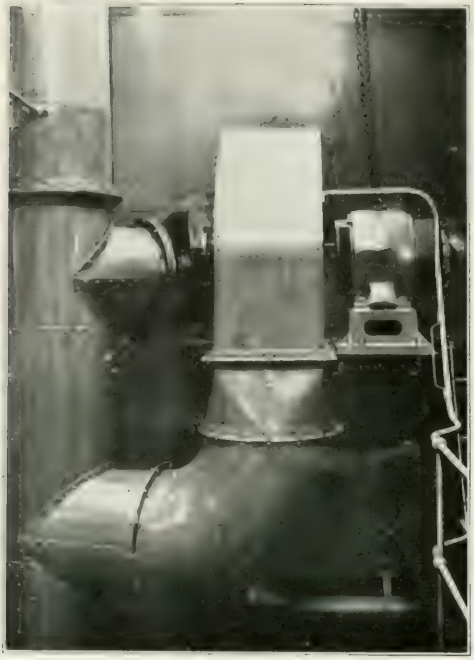


View of one of the CO_2 Machines, showing Steam Cylinders and Gauges.

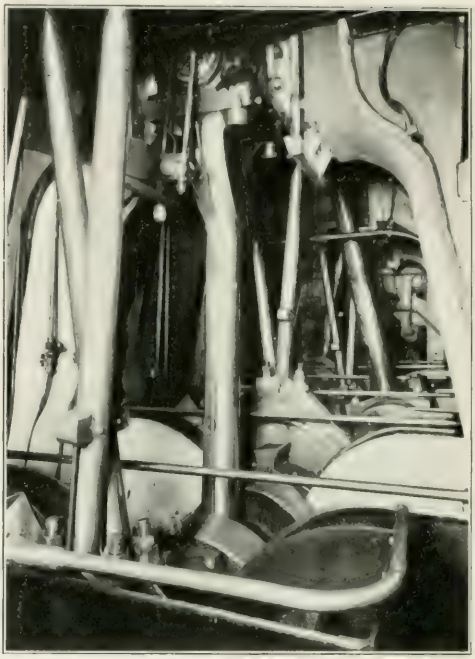


Brine Distribution Tank, showing Valve Controls for Pipe Nests.

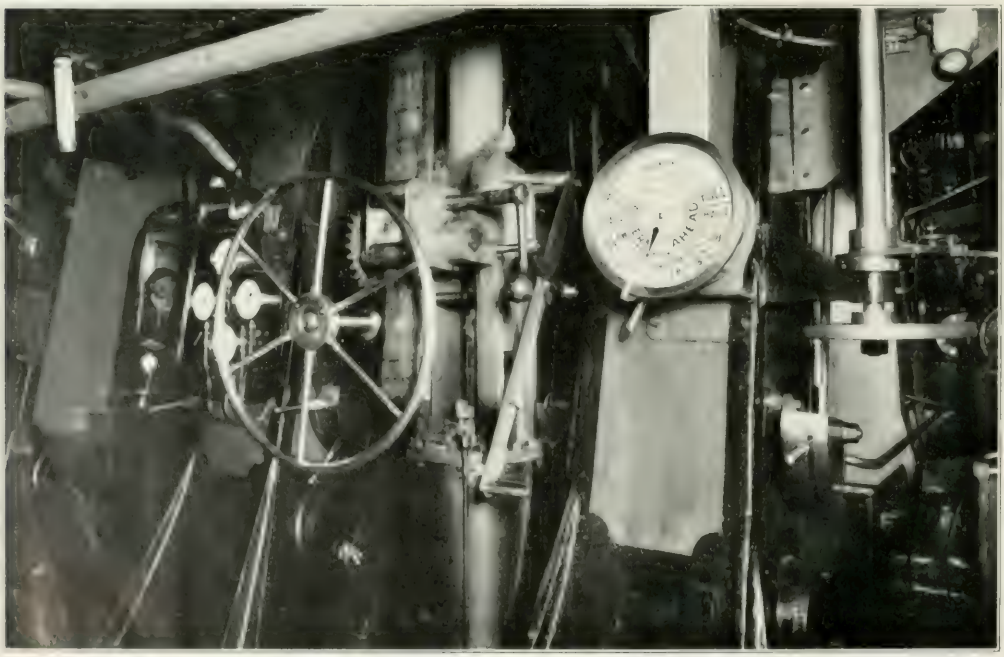
MACHINERY OF THE "PORT HARDY."



Fan and Motor for Engine Room Ventilation.



View looking along Port Crank Pit, taken from Forward.



Control Platform for Port Engine, showing Telegraph and Reversing Handle.

engine having cylinders 22½, 38 and 63½ by 48 in. stroke, designed to run at 85 r.p.m. and developing 4,500 i.h.p.: the thrust blocks are of the Michell type, and these are forced lubricated from pumps driven off the main engine.

The main condensers, which are of the uniflux type are carried on the outboard side of the main engine and have each 2,500 sq. ft. exposed area. The air pumps for supplying the necessary vacuum are driven by levers of the main engines and the main circulating pump is turbo-driven. A stand-by circulating pump, situated on the starboard side of the ship, as a glance at the general out-lay of machinery will show, is driven by one of two high-speed enclosed crankpit reciprocating engines.

Propellers.

The propellers are of the built type, each having four loose manganese-bronze blades bolted to a cast-iron boss which has a diameter of 4 ft. 1 in.

The following are the diameters of the various sections of the propeller shafts, which are of Siemen's-Martin ingot steel :—

Crankshaft	13¾ in. diam.
Thrust shaft	13½ in. ,,
Intermediate shaft	12¾ in. ,,
Tail shaft	14¾ in. ,,

We illustrate on page 132 the flat at the aft end of the shaft tunnels, showing the spare tail shaft and value distribution boxes to aft tanks. The arrangement of the main and auxiliary machinery seems to be quite commodious, and there is plenty of space for access to the manœuvring controls; the starboard starting position we reproduce elsewhere, and this photograph shows also one of the main telegraphs which is a product of Robinson & Co. Limited, Liverpool; the revolution counter, which will be noticed in the background, is of the Harding's improved pattern.

The length of the engine room is 30 ft. 10½ in. and that of the thrust recess 19 ft. A point of interest arises in the method of ventilating the engine room. The motor, which we show elsewhere, drives a fan which can either supply air or exhaust it from the engine room through the vent "legs," as will be seen, and any one "leg" can be cut off if necessary by means of louvres. The motor is a shunt wound direct-current motor, developing 4½ h.p. at 460 r.p.m., giving 42 amps. at 100 volts. It is supplied by the Sunderland Forge Company.

Boiler Room.

The boiler room is 45 ft. 1½ in. in length; steam is supplied by four boilers of the horizontal multitubular Scotch type, working at a steam pressure of 200 lbs., with superheaters of the Schmidt type fitted to give 200 degrees superheat. Howden's system of forced draught is fitted to the boilers.

Each boiler is fitted with four Morison type furnaces of 3 ft. 7 in. diam. The funnel has an internal diameter of 9 ft. 9 in. and a height above the centre line of boilers of 88 ft. 5½ in.

The feed-water arrangements consist of a Weir's direct-contact feed-water heater fitted with the usual float, which we illustrate elsewhere, one main and two auxiliary feed pumps of reciprocating type, which we mention later, and an Edmiston feed filter of the type supplied by the Glasgow Patents Limited. The Cumberland electrolytic system is fitted for the determination of salinity of the feed water; this and the Edmiston feed filter we illustrate on page 132.

Auxiliary Machinery.

We give in the next column a complete list of auxiliary machinery which should prove of great interest, since it gives a very comprehensive idea of the types of machinery fitted and their sizes.

Table of Auxiliary Machinery.

Auxiliary.	No.	Maker.	Size.
Main auxiliary pump	1	Paul....	16 in. reciprocating.
Main auxiliary pump	1	Weir	16 in. (turbine).
Main air pump	2	O.M.E.	23 in. diam. by 24 in. stroke.
Main feed pump	2	Weir	10 by 13½ by 21 in.
Auxiliary feed pump	1	Mumford	6 by 9 by 10 in.
Feed pump	2	O.M.E.	6 in. diam. by 24 in. stroke.
Bilge	2	O.M.E.	6 in. diam. by 24 in. stroke.
Forced lubricating pump	1	Weir	8 by 9 by 18 in.
Auxiliary air pump	1	Weir	15 by 9 by 12 in.
Auxiliary circulating pump	1	Paul	8-in reciprocating.
Ballast	1	Mumford	8 by 10 by 10 in.
F. and bilge	1	Mumford	7 by 8 by 8 in.
Distiller and W. deck ..	1	Mumford	7 by 8 by 8. in.
Emergency b.p.	1	Lamont	6-in. suction motor, driven 9 by 8 in. stroke.
F.W. pump	2	Mumford	5 by 5 by 8 in.
Sanitary	1	—	6 by 7 by 8 in.
Evaporator	1	Weir	80 tons.
Fan and engine	1	Howden	90 in. fan.
Lubricating oil pump	1	O.M.E.	2½ in. diam. by 8 in. stroke.
Sanitary pump	1	O.M.E.	6 in. diam. by 12 in. stroke.

The following auxiliaries are driven off the main engine :—

Two main air pumps	23 in. diam. by 24 in. stroke.
Two feed pumps....	6 in. diam. by 24 in. stroke.
Two lubricating oil pumps	2½ in. diam. by 8 in. stroke.
Two bilge pumps	6 in. diam. by 24 in. stroke.
One Sanitary Pump	6 in. diam. by 12 in. stroke.

The main circulating arrangements have been mentioned already; the main turbo-driven circulating pump is of the Weir 16-in type, and the auxiliary circulating pump is of the centrifugal type, driven by a high-speed reciprocating engine supplied by Matthew, Paul & Co., Dumbarton.

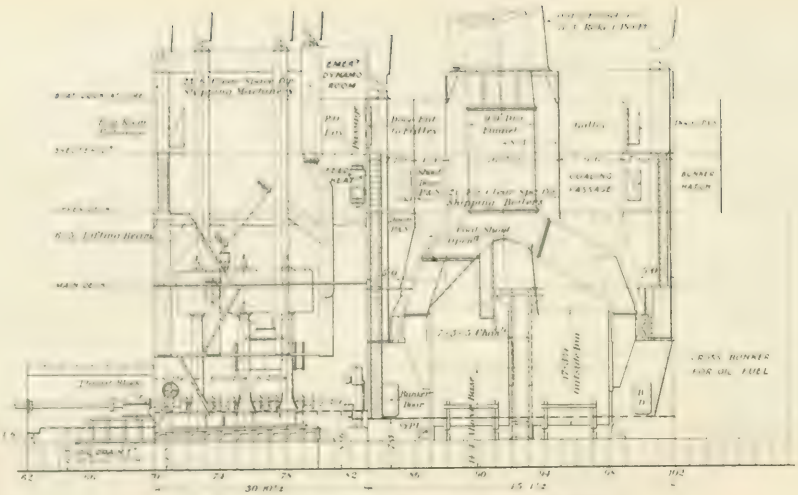
The auxiliary condenser is of the ordinary type; its circulating pumps, which we illustrate elsewhere, is supplied by the makers of the auxiliary main circulating pump, and the air pump for the auxiliary condenser is a Weir monotype pump. The auxiliary feed pumps are supplied by Mumford's, of Colchester, and the main feed pump is one of Weir's type. For particulars of the remaining auxiliary machinery the reader is referred to the appended table. On page 129 we illustrate an observation board on which are fixed various steam gauges which are of the type manufactured by Dewrance & Co., London, and also thermometers, which are of the special type made by the Scientific Instrument Company, Newcastle-on-Tyne. The Auld patent reducing valve, illustrated on page 130, is fitted for the purpose of reducing the steam pressure to the 120 lbs. per square inch required in the refrigerating engines. The pressure guage, shown on the right of the value, is of the Bourdon type.

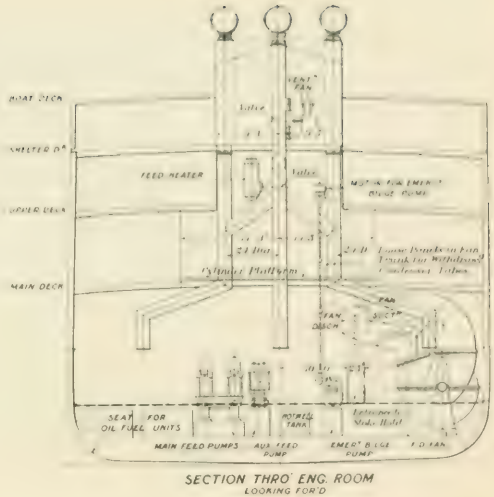
Generators, &c.

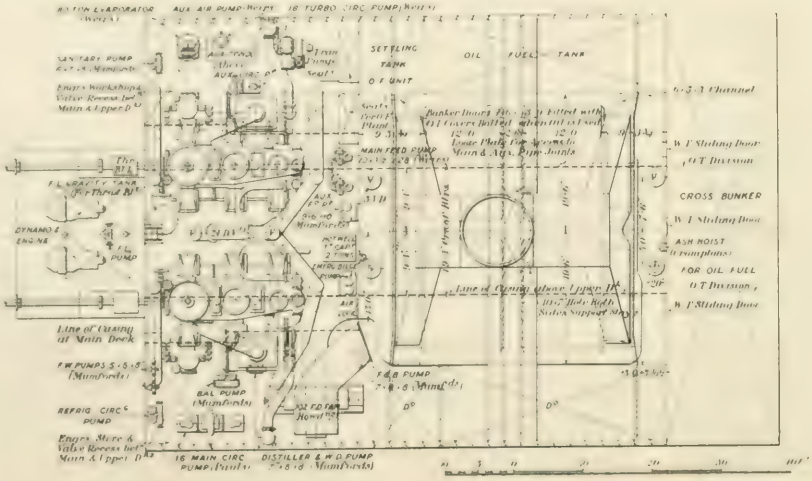
The generators are arranged as shown in the plan, and we also illustrate them elsewhere. There are two units, each consisting of a generator giving 260 amps. at 100 volts and running at 275 r.p.m. The generator is direct-coupled to a Howden high-speed forced-lubrication reciprocating engine. The pump situated between the two generators is an auxiliary forced-lubrication pump for the Michell thrust blocks. The steering engine, situated on a level with the crew space aft, and well protected from heavy weather, is of the steam-driven type, manufactured by Hastie & Co. Limited, and is controlled from the bridge by a Mactaggart-Scott telemotor gear.

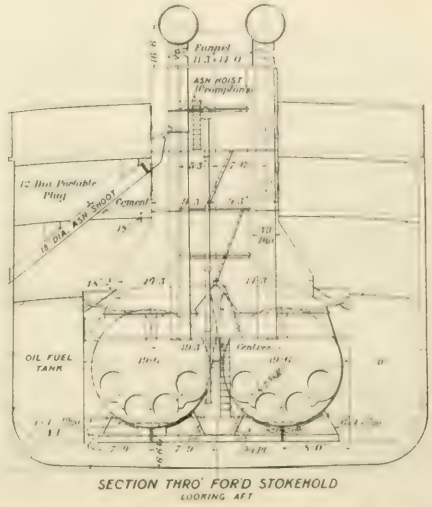
Refrigerating Machinery.

The refrigerating machinery is of the CO_2 type. There are









The Commonwealth and Dominion Liner "Port Hardy." General Arrangement of Machinery Space Sections through Engine Room and Boiler Room.

two distinct units, and we illustrate two views of one of them elsewhere; each engine takes steam at 120 lbs. per sq. in., runs at 70 r.p.m., and is coupled up to a 5½-in. compressor.

The system of freezing is that of the actual distribution of brine through nests of pipes arranged in the holds in the usual manner, arrangements being made whereby warm or cold brine can be circulated, according to the nature of the cargo. We illustrate one of the brine tanks, and the photographs show the controls for pipe distribution, *i.e.*, for shutting off a given number of coils, and also a distribution box, the valves on one side controlling the warm brine for chilling purposes, and those on the other side the cold brine for freezing purposes; spare CO_2 bottles will be noticed on the bulkheads. There are three brine distribution (see photograph) pumps which are of the direct-acting type, supplied by Mumford's Limited, Colchester, and working at 14 double strokes per minute. On the bulkhead leading to the engine room is situated the steam coil for thawing out, and this we illustrate elsewhere. The insulating material is granulated cork, and the insulation of the holds has been carried out by Gregson's Limited, London.

SOME NOTES ON THE LONGITUDINAL ADJUSTMENT OF TURBINES.

The longitudinal adjustment of a turbine is arranged for by means of the thrust block. Thrust collars are turned on the shaft just as in the case of ordinary reciprocating engines, but the thrust block, in turbine machinery, is fitted outside the forward end of each turbine casing. Also, this adjusting block is in halves in such a way that the lower half takes the ahead thrust and the upper half the astern thrust, being also capable of separate adjustment. It is of steel, and is grooved out to receive brass rings, the edge of the groove being then well caulked into the ring. Through the rings, excepting the end ones, holes are drilled and gutter ways cut from these to the edges; this is to allow a good circulation of oil, and, as the end rings are not drilled, this prevents the oil escaping too easily. The rings in the bottom half bear against the forward faces of the collars on the shaft, and those in the top half against the after faces of the shaft collars, when in the normal or working position, the rings all being bedded on to the shaft collars, to ensure that each is doing its work. When the rotor dummy has the requisite clearance, the bottom half of the block is brought hard up against the forward side of the shaft collars, and in a space at one or both ends of the block, brass liners are fitted, the effect of which is to prevent the shaft working forward. The top half is then put on, and by means of screw gear is brought forward so that the rings bear against the after-side of the thrust collar. It is then set aft until there is a clearance of from 4 to 6 thousandths between rings in top half of brush and collars of shaft for lubrication purposes, being then secured in this position. The bolt holes in the thrust block are oval, being larger than the bolts to allow for the foregoing. In practice, it is found that the wear on the thrust block is nil, the propeller thrust being balanced by the pressure of the steam acting on the vanes in the opposite direction. It will be seen from the foregoing description that the top half of the block may be moved by the screw gearing attached, but in the case of the bottom half, it can only be moved forward or aft by decreasing or increasing the thickness of the liners fitted. To adjust the dummy clearance: this is obviously the longitudinal adjustment of the turbine. By means of the dogs and gear provided, bring the rotor up until dummy rings and grooves are in actual contact; now note clearance at finger plate in this position; and then screw back rotor until clearance at finger plate is increased by, perhaps, 30 thousandths. The liners of thickness requisite to bring the lower half and thrust rings up against the forward faces of shaft collars can then be fitted in place and the lower half will then be locked in position. The upper or astern position of the thrust is dealt with thus: Ease back nuts of collar studs and work adjusting screw till rings and collars are in actual contact by cover moving forward. Now tighten cover stud nuts and screw back adjusting stud till "feelers" between it and the turbine casing show the necessary clearance for oil, say, six thousandths. Then ease back cover nuts and tap on top half till this clearance becomes nil; then screw cover bolts down hard. Thus there is an oil clearance of about six thousandths, the dummy clearance being, as explained, 30 thousandths. This operation of adjusting clearance should always be done with the turbine thoroughly hot, and as this clearance is a most important detail in the economy and efficiency of the turbine, it must always be very closely and carefully observed.

TEMPERATURE AND THE STRENGTH OF MATERIALS —*Continued from page* 126.

figure. The method of "colonizing" was only fully described in the *Marine Engineer* in July last year. This treatment consists of heating metals in retorts in a reducing atmosphere with a mixture containing finely divided aluminium, and so thoroughly infuses aluminium into the exposed portions dealt with that a homogenous aluminium alloy is formed for a certain depth, ranging as required for surface treatment to the permeation of the entire mass. This method is primarily a protection against burning, and "colonized" metal will sucessfully withstand temperatures up to 1,800° Fahr. without deterioration. This figure, as has been shown, is far above any of the recorded best results quoted, and will, of course, prove even more efficacious below this limit. From the point of view of erosion, there is much less to fear than there is in the effect of temperature on strength as far as turbine discs are concerned. Holzwarth, it should be noted, in the various gas turbines he has built, contented himself with comparatively low blade speeds—about 540 ft. per second, so that his disc stresses were fairly well covered by the use of electro-steel, but the low blade speed meant a low impinging velocity of gas, and hence a weak mixture, so that the potential efficiency of his machine suffered accordingly. Before the internal-combustion turbine can encroach—if it ever does—on the field of the large marine oil engine, much more work requires to be done on rotor material. That we have an alloy to-day that will stand 1,000°-1,200° Fahr. is not sufficient. The time factor has an important influence on the question of reliability, in the case of alloys the tendency has often been for the constituent elements to separate out under the combined effect of heat and the duration of its application. It must not be forgotten, however, that blade speeds and steam temperatures are in daily use to-day which only ten years ago were very far from realisation. Just as they came into being to supply a demand, so it seems certain that, with application to the subject, much higher speeds at much higher temperatures will be rendered equally possible by improvements in material in the direction of superior heat-resisting qualities.

ELECTRIC SHIP PROPULSION.*

By W. L. R. EMMET.

The first proposals for the use of electric motors to propel large ships were made long before gearing of a type and speed suitable for this purpose had been developed. The first actual applications to large ships were begun about the same time that the earliest applications of gears were made. The first large ship driven by a turbine with a generator and motors was the United States collier *Jupiter*. This installation was made by the U.S. Navy for the purpose of testing the practicability of the method with a view to its possible use in warships. The writer, who designed this *Jupiter* equipment, had for a long time been urging the use of electric drive for large battleships in which it seemed to afford many advantages of great value. While the *Jupiter* was a type of ship in which the advantages of electric drive were relatively small, the equipment was an unqualified success; the fuel economy was much better than in the two sister ships *Cyclops* and *Neptune*, one of which was driven by reciprocating engines and the other by geared Parsons turbines. The *Jupiter* has been in service for ten years and has cost practically nothing for maintenance of machinery.

Experience with the *Jupiter* convinced many officers of the Navy that this method was desirable for large warships, and the growth of this belief has led to the application of turbo-electric drive to all the large vessels designed by the American Navy within recent years, except some very high-speed, light scout cruisers in which geared turbines were used. The ships completed, or partially completed, in which this method has been used include seven 30,000 h.p. battleships, four 60,000 h.p. battleships, four 180,000 h.p. battle-cruisers and one collier.

Advantages of Electric Propulsion.

Much has been published concerning the details of the installations made for the U.S. Navy, and the advantages which they have sought to afford, and it is only through the study of detail in specific cases that sound ideas can be formed as to relative merits of different kinds of machinery for different ships. In this paper it is intended to show the possibilities of turbo-electric drive application in a type of ship in which it has never been used, namely, a large passenger ship, but before doing so it may be well to review some of its advantages in warships.

The adoption of this method enables us to greatly simplify the turbine, using a plurality of units with the speeds which are most convenient, and to place these units in positions which are safest and most convenient. Reversing turbines are avoided and very large reversing power afforded. Interchangeability is afforded which makes possible continuation of operation when part of the apparatus may be damaged, and also makes possible running at reduced speed with only a part of the apparatus in use.

With electric drive changes of connection can be made which afford a change in ratio of speed reduction, and this feature, in combination with the ability to use only a part of the generating units at reduced speed, gives a very large gain in economy at such reduced speeds as must be used in cruising, where fuel consumption governs the effective radius of action.

Electric drive involves no mechanical function other than simple rotation. Lubrication becomes simple and inexpensive, and labour and maintenance are reduced to a minimum. Large electrical apparatus of such voltages as are used in ships is extremely simple, and in ships, as in other cases, rarely gives trouble. Such apparatus, when damaged, is generally very easy to repair with facilities which are available anywhere.

Case of a High-speed Cruiser.

An example of the possible expediency of electric drive to a type of warship in which geared turbines have their best and simplest application may be interesting. We will consider a 32-knot fast cruiser using 120,000 h.p. at full speed. If this ship were equipped for electric drive the machinery would weigh about 10 lb. per horse-power more than a suitably geared turbine equipment. She would have four generating

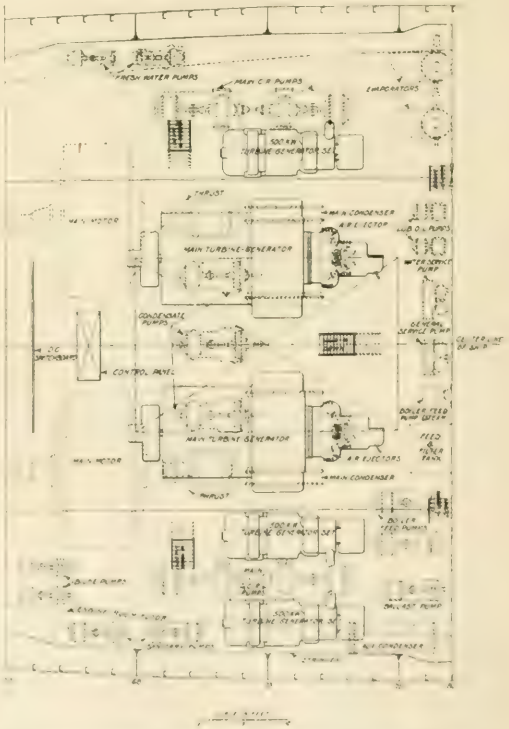


Fig. 1.—General Arrangement Plan of Turbo-Electric Machinery for 24,500 h.p. Ship.

units; could run about 29 knots with three of them, 26 knots with two, and 19 knots with one, and the steam consumption per horse-power at all these speeds would be very nearly the same. At 19 knots, with one generator, with motors arranged to give the best turbine speed, the turbine efficiency would be actually better than at full speed because the turbine would be less congested. With suitable arrangements and voltage adjustment the efficiency of electrical transmission will be as

* Paper read before the Spring Meeting of the Sixth District, Section of the [illegible] Naval Architects, March [illegible].

good at 19 knots as at full speed. One of the greatest advantages of the electric drive under these conditions would be that three of the four sets of auxiliaries used at full power would be shut down entirely. In a geared ship all of the turbines and gears, with their auxiliary equipment, would, at 19 knots, be operating at one-half speed and one-eighth load.

With this low power and speed, the efficiency of a turbine is greatly impaired. A ship turbine designed for best adaptation to such work will use about 52 per cent. more steam per merit in turbine design could not do better than 1·27 lb. of oil per shaft horse-power hour.

The difference of weight between the two equipments will be about 535 tons, and this at 19 knots will be compensated for in 3,600 miles of run. And the comparison at lower speeds would be about similar. Such an electric ship could run at 19 knots from England to the Falkland Islands and, starting with 2,300 tons of oil fuel, would have 200 tons left on arrival. A similar geared ship, filled to equal displacement by carrying

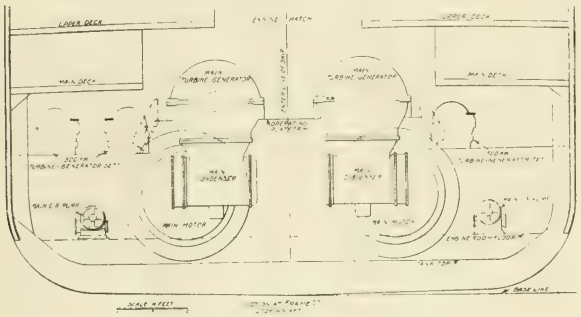


Fig. 2.—Engine-room, 24,500-H.P. Ship.

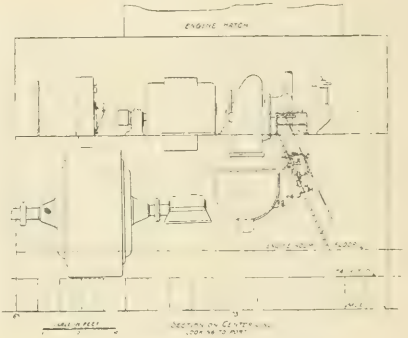


Fig. 3.—Engine-room, 24,500-H.P. Ship.

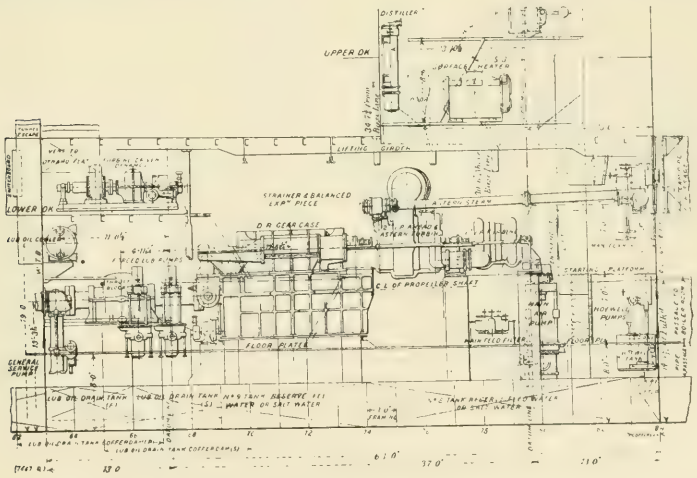


Fig. 4.—Engine-room, *Empress of Canada*.

Figs. 2, 3, and 4, showing Section and Elevation of Proposed 24,500 h.p. Ship, and Elevation of Engine Room, "Empress of Canada."

horse-power with the lower speed and power. The gears will be at least 3 per cent. less efficient at this very low load and, in most turbine-driven warships, the auxiliaries at such speeds add 25 per cent. to the water rate. Thus, without saving through the use of cruising turbines, we might expect to use 80 per cent. more steam. By the use of cruising turbines this might be reduced to 60 per cent. For comparison we will assume 50 per cent. as the minimum difference that could exist between properly designed equipment under these conditions. On this assumption the electric ship will use for all purposes, at 19 knots with saturated 250 lbs. steam, 0·85 lb. of oil per shaft horse-power hour. A geared ship with similar 2,835 tons of oil, could not reach at this speed within 700 miles of the distance.

These figures, which are conservative, show that such qualities as are afforded by the electric drive may have great military value, even in a light, high-speed ship where the weight increase of machinery might at first sight be thought prohibitive.

Statements and Proofs.

The comparison which is here made may seem inconsistent with some claims of low-speed economy made by builders of geared-ship machinery. It nevertheless agrees with the

[illegible] tests and it should be remembered that turbo-generators are constantly being tested by the manufacturers. [illegible] ship turbines without generators are not. Many claims entirely inconsistent with the known possibilities have been made in connection with ship turbines. In all the large naval vessels equipped with electric drive the results shown by careful tests have agreed closely with those predicted and indicated by calculations and by shop tests. And in these we constantly know the results from the electrical readings.

Gear Limitations.

Since the turbine is much more efficient than the reciprocating engine, if we are to have steamers, we must have either geared-turbine ships or electric drive. The possibilities of the geared turbine are well understood and need not be much discussed here. It may, however, be well to touch upon certain matters which have been quite generally overlooked in this connection. The writer can speak from some experience in this matter. The General Electric Company has, under his direction, been one of the largest producers of geared-turbine ship machinery, having built about 350 ship equipments of this type aggregating over two million horse-power.

Four large sets of gearing, ranging from 2,000 to 6,000 h.p., have been elaborately tested for efficiency. Apparatus has

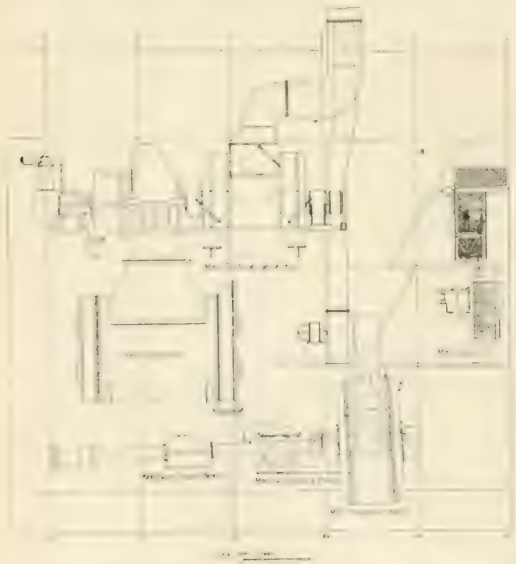


Fig. 5.—I.J.N. S.S. "Kamoi" Machinery Lay-out Profile.

been built and carefully observed to show and record torque variations in service, and an equipment has also been built and used to show distortions of gear structures through movements and vibrations of ships at sea. Much has also been learned of geared turbine possibility through observations of many electrically-driven ships where load and torque variations are constantly visible on the electrical instruments.

While from such experience and that of others it can be said that with suitable knowledge geared turbines can probably be applied with success to almost any type of vessel, it must also be said that such application involves more possibilities of trouble than has been generally supposed. An electrically-driven ship has shown, through its electrical instruments, in a heavy seaway, a torque on propeller shafts more than three times as great as the normal full-speed torque. A geared ship with a high-speed turbine would, under similar conditions, be subject to a similar overstrain.

Distortions of gear casings, installed in the solidest manner, have been observed in heavy weather and these movements have been large enough to indicate very large variations of strain distribution. Vibrations of ships, particularly in heavy weather, are imparted to gears, and through the inertia of the parts affect the evenness of engagement.

Low-speed turbines are safer and easier to apply through gearing than high-speed turbines, but they are also heavier, more complicated, and less efficient than high-speed turbines.

A Passenger Ship.

As an example, to illustrate the possibilities of electric drive in a large passenger ship, the case of a vessel like the *Empress of Canada* has been taken. The machinery of this ship was well illustrated in *Engineering* (London), September 1, 15 and 29 and October 13, 1922, and for comparison an illustration, Fig. 4, from that article, showing elevation of machinery

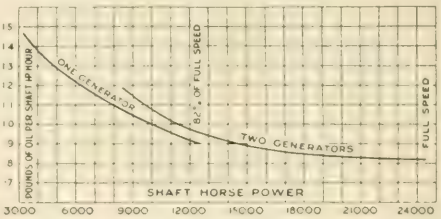


Fig. 6.—Curves showing Fuel Rates for all purposes for Ship of "Empress of Canada" Type, fitted with Electric Drive.

and space is here given. Drawings, Figs. 1, 2 and 3, are also given, showing possible arrangement of electric-drive machinery in such a ship. In these all the machinery is shown in an engine room made as short as possible. Such an arrangement with generating units on a higher level is often very desirable, but various other arrangements could be used. Motors could be put in separate spaces nearer the propellers, which might effect some saving in shafts, &c.

Fig. 6, above, shows by curves the fuel rates for all purposes which should be given by such a ship when operating

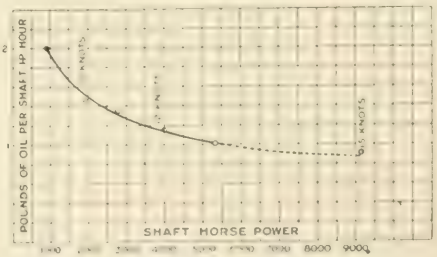


Fig. 7.—Curve showing Oil Consumption for all purposes on Japanese Fuel Ship, "Kamoi," as indicated by Tests made on Voyage between New York and Honolulu.

with two generators and with one. For purposes of comparison and verification of the claims here made a curve and test figures from the fuel-ship *Kamoi* of the Japanese Navy are also given. Fig. 7, the *Kamoi*, a 9,000 h.p. 15-knot ship,

was recently completed by the New York Shipbuilding Company, with machinery built by the General Electric Company. The figures given were obtained by test during her first voyage. The differences between the performances of the *Kamoi* as shown and of the larger ship, as indicated by Fig. 6, are fully accounted for by the difference in size of the generating units and by more advantageous auxiliary and feed heating arrangements. The results reported from the *Kamoi* are in good agreement with calculations based upon factory test of her generating apparatus, and clearly indicate that the figures predicted for the larger ship are conservative.

The figures upon which curves in Fig. 6 are based are given in the tabulation below. The steam conditions assumed are 245 lb. G at the throttle, 150 deg. superheat, and 28·5 in. vacuum.

Most of the axuiliaries are driven from two condensing turbine direct-current generating units, with a third provided as a spare.

Excess steam needed for heating the boiler feed from 85° Fahr. up to 220° Fahr. is extracted from the main units at 10 lb. gauge pressure. At all loads it was assumed that sufficient steam is taken direct from the boilers to evaporate 27 tons of fresh water per day. This requirement would need 200 lb. of oil per hour.

The apparatus includes two generating units, each having a capacity of 9,500 kw. and weighing, without condenser, 195,500 lb., and two motors, each of 12,250 s.h.p., and weighing 236,000 lb. The combined weight of these parts, with the control equipment, is 911,400 lb., or 37·2 lb. per shaft horse-power. The results obtainable with such equipment are shown by the table in the opposite column and by the curves in Fig. 6.

Operating Tests I.J.N. Fuel Ship "Kamoi."

Speed, in knots.	R.P.M.	Coal, tons per day.	Oil, tons per day.	Shaft H.P.
11	86	29·29	21·32	2,740
11	86	16·9	29·1	2,723
11	86	38·4	16·7	2,735
11	86	28·84	21·1	2,738
10	78	48·8	0	1,996
10	78	36·7	7·8	1,985
10	78	30·7	10·7	1,995
10	78	23·7	15·2	1,920
10	78	23·6	15·6	1,934
12	94·3	14·9	42·1	4,117
12	94·5	25·15	34·6	3,920
12	94·4	44·45	23·2	3,945
13	102·1	43·85	32·4	5,300

Builders' Trials at 15 Knots.

Approximate coal consumption (coal alone) first three hours, 11,400 lb. per hour; average shaft horse-power, 9,108.

Approximate fuel consumption second three hours: Oil 6,792 lb. per hour and coal 1,500 lb. per hour; average shaft horse-power, 9,046.

Conditions: 241 lb. G at throttle, 150 deg. superheat, 28·5 in. vacuum. Feed heated to 197 deg.

Through a mistake in opening valves, 5 out of 19 nozzles were unnecessarily operated in a throttled condition which must have occasioned a loss of about 2 per cent.

Per cent. of full speed.	Total S.H.P.	Motors. R.P.M.	Motors. Efficiency.	Generators. R.P.M.	Generators. Efficiency.	Main Turbines. Efficiency.	Main Turbines. Steam lb. per S.H.P. hour.	Auxiliaries. Electric Load, kw.	Auxiliaries. Steam lb. to Generator Unit per hour.	Auxiliaries. Other Steam lb. per hour.	Steam lb. Main Units per hour.	Steam lb. Make-up per hour.	Extracted Steam, per cent. of total.	Boiler Efficiency.	Lb. Oil all purposes, S.H.P. hour.
			Per cent.		Per cent.	Per cent.								Per cent.	
Two Generators. Two Motors.															
100	24,500	112	97·5	2,464	96·75	76	8·8	800	14,000	11,000	229,000	2,500	10¼	75	0·811
82	12,200	90	97·1	1,980	96·5	67	10·1	620	11,400	8,800	129,500	2,500	9½	75	0·965
One Generator. Two Motors.															
82	12,230	90	96·9	1,980	97·0	72·6	9·2	550	11,000	7,800	119,700	2,500	10½	75	0·90
53	3,260	56	95·5	1,232	96·0	52·0	13·2	360	6,500	7,000	46,000	2,500	7¾	75	1·46

Table showing Figures upon which the Curves in Figs. 6 and 7 are based.

Sir W. G. Armstrong, Whitworth & Co. Limited are to build a twin-screw motor passenger and cargo liner, 600 ft. long, 72 ft. in breadth and 42 ft. in depth, and of 17,000 gross tons, at their High Walker yard for the Swedish-America line of Gothenburg, one of the five lines controlled by Aktiebolaget Broströms Linjeagentur. The cost of the ship will be, it is stated, over a million sterling. The engines will be supplied by Burmeister & Wain, Copenhagen, and will be the first of a new double-acting four-cylinder type, which are stated to represent a great advance in Diesel motor engineering. They will develop 13,500 s.h.p. and give the vessel a speed of 17¼ knots. The vessel will carry 1,600 first, second and third-class passengers, and will sail between Gothenburg and New York,

New Dutch Lightship. On March 2 the lightship *Maas* was launched from the yard of the N.V. v/h J. & A. v.d. Schuyt, Papendrecht. This ship is under construction for the Dutch Government's coast lighting department and is of the following dimensions:—

Length overall	152 ft.
Breadth, moulded...	24½ ft.
Depth, moulded	13 ft.

On a draught of 10½ ft. the displacement will be 426 tons. The ship will be the only Dutch lightship to be self-propelled and will be fitted with two "Polar" Diesel engines of 60 h.p. each. The latter is an interesting fact when it is remembered that the German practice is usually to make their light vessels self-propelling. British and Irish lightships are all of the non-self propelling type.

THE INFLUENCE OF FORM UPON THE STABILITY AND PROPULSION OF PASSENGER SHIPS.*

By JOHN ANDERSON.

A cursory glance at the Transactions of this and other kindred institutions shows that while the forms of merchant vessels have been discussed at great length with regard to propulsion, the discussions on stability have been, until recently, largely confined to methods of measuring metacentric heights, the range of stability due to freeboard, the effect of free surface, the influence of bilge keels, and so on. Some remarks on the points which particularly interest the writer, with regard to stability, appear in the paper read to this Institution by Mr. L. Peskett in 1915, also in the paper

FIG 1.

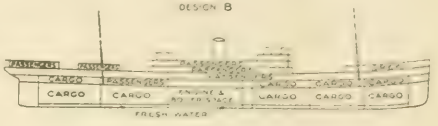



FIG 2

FIG 3

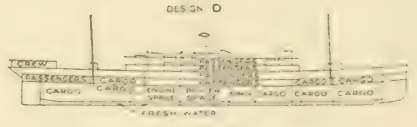



FIG 4

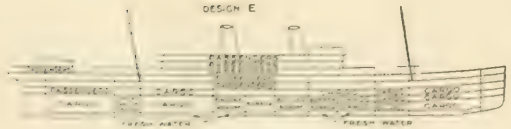
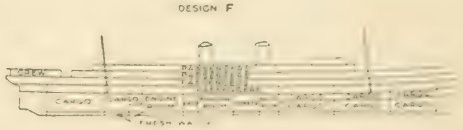


FIG 6

Diagram showing Outline Profiles of Designs mentioned in the Paper.

sand or other ballast (in addition to their water ballast), it is thought that the design of hull, to meet all recent developments, should be reviewed. Half a century ago, the practice for moderately high-speed vessels was to make the breadths of about one-tenth of the length, a common belief at that period being, I understand, that speed could not be obtained economically if the breadth exceeded this proportion. These ships were deep in relation to their breadth, and the only erections imposed upon their structural decks were the necessary entrances and the master's house. The chief characteristics

delivered by Sir John Biles in Paris last year. The former suggested that "the G M in the *seagoing condition* should be the minimum commensurate with safety," while the latter suggested that large passenger ships should be designed for "a range and a limit of G M in the *light condition*." It was stated that the second proposal contained a margin which would allow for reasonable additions being made during the construction of the vessel. The balance between these extreme conditions is dependent upon the amount of cargo carried in relation to the total volume of the vessel and on the vertical disposition of the cargo, fuel and fresh water, and it is thought that, generally, the two opinions which have been quoted would be in conflict when applied to the large vessels of to-day, which are designed primarily for the carriage of passengers. The present slump in freights has shown that passenger ships may be required to proceed to sea without any cargo whatsoever, and as many modern ships can only do so when weighted with

of their forms were V-shaped sections at both ends and a very high rise of floor, and both of these features somewhat assisted stability in the light condition, although they did not provide an adequate amount, and the vessels had to be further assisted by special dispositions of cargo when loaded, and by the introduction of large quantities of sand or other ballast when returning without cargo. Since that period developments have been continuous and rapid in the direction of increased superstructure and freeboard, extra deck equipment, re-disposition of structural material, and the adoption of forms which are beneficial for propulsion, but detrimental to stability. Breadth has been greatly increased to meet these developments, but the alterations in design, in conjunction with the larger percentage volume which is utilized for passenger space (which has the effect of placing the cargo at a lower level), have resulted in present-day ships having an excess of necessary stability in the loaded condition and a deficiency in the light condition. Although there are cases where the breadth has been decided to suit cabin arrangements, its amount has generally been fixed to suit some standard for stability, and each increase

* Paper read at the Spring Meetings of the Sixty-fourth Session of the Institution of Naval Architects, March 23.

seems to suggest further extensions of the top-side arrangements, which may largely nullify the benefits of the increased breadth. The factor of first importance appears to be the provision of a minimum amount of metacentric height in the seagoing condition, and the question immediately arises, What is the minimum for such a condition. The writer suggests, as the results of observations.

TABLE I.—THE INFLUENCE OF FORM UPON THE STABILITY AND PROPULSION OF PASSENGER SHIPS.

Ballast Conditions of Passenger Ships designed for a Fixed Amount of Deadweight.

Item.	Vessel 550 ft. 66 ft. 3 in. × 45 ft. with Double Bottom and Deep Tanks. G.M. in Light Condition = Neutral.			Vessel 550 ft. × 67 ft. 9 in. × 45 ft. with Double Bottom only. G.M. in Light Condition = 1 ft.		
	Tons.	Vertical C.G.	Vertical Moment.	Tons.	Vertical C.G.	Vertical Moment.
Light ship	10,150	30·2	306,520	10,300	30·4	313,100
Double bottom	1,800	2·3	4,140	1,800	2·3	4,140
Deep tanks	2,100	15·0	31,500	-	-	-
	14,050		342,160	12,100		317,240
Vertical C.G. above base	24·35 ft.			26·22 ft.		
Ballast draught	20·90 ft.			18·20 ft.		
M.G.	3·55 ft.			3·60 ft.		
Righting moment (displacement G.M.)	49,880 ft.-tons			43,560 ft.-tons		

during varying conditions at sea, that the following, although in some respects an indefensible formula, might be used as a quantitative index of the minimum amount necessary :—

$$\text{G.M.} = \frac{0{\cdot}70}{b} \times \frac{\text{R}}{\text{A}}$$

where b is the block coefficient. R is the longitudinal vertical area above the waterline, and A the longitudinal vertical area below the waterline.

It will be understood that the results given by the foregoing formula might not provide sufficient stability in a damaged condition. This contingency would require separate consideration and would generally be dependent upon the internal arrangements of the vessel. To obtain the ideal amount when loaded, some designers have been prepared to accept dimensions which would yield a neutral or even a negative G.M. in the light condition, while others have chosen a positive G.M. when light, and sought to obtain a damping effect in the loaded condition by the introduction of anti-rolling appliances : the addition of such appliances may greatly increase the cost and weight of a vessel, and are therefore objectionable. Obviously a G.M. of, say, a foot in the light condition cannot in itself be considered sufficient for a vessel of, say, 66 ft. breadth, as such a vessel would be unduly sensitive to changes ; for instance, the emptying of a double-ended boiler in the wings would give the excessive inclination of, roughly—

$$\frac{50 \text{ tons} \times 20 \text{ ft.}}{10{,}100 \text{ tons} \times 1{\cdot}0 \text{ G.M.}} = 0{\cdot}10 = 6 \text{ degrees.}$$

A vessel must therefore be assisted in such a condition by ballasting and this raises the question, Is it better to provide for additional water ballast in deep tanks in conjunction with reduced breadth for ballast seagoing trim than to design for, say, a foot of G.M. when light (which would give a greater excess than at present when loaded) in association with ballast in the double bottom only ? The figures in Table I. illustrate the effect of these alternatives and suggest to the writer that deep tanks are preferable to increased breadth, provided they are always available for use, also that they are now necessary for providing sufficient ballast when the double bottom is used extensively for the carriage of oil fuel and fresh water. The subdivision arrangements proposed at the International Conference for vessels of less than 0·50 permissible factor appear to lend themselves to designs embodying deep tanks, as is shown by Fig. 5 (Design E). Table II. contains data for vessels of different types (the profiles of which are shown by Figs. 1 to 6) under varying conditions of loading, and the alternative figures given in the second column for each type indicate the G.M. suggested by the proposed formula. It will be seen that the intermediate type A, which has a fairly full model, has a reasonably good balance throughout, but in the others, as the superstructures are increased, or as the block coefficients are reduced or the ratio of volume for passengers is increased, there is a deficiency in the light condition and an excess when loaded. It will be noticed that in some cases the amount shown for the arrival condition when loaded is less than

TABLE III.—THE INFLUENCE OF FORM UPON THE STABILITY AND PROPULSION OF PASSENGER SHIPS.

Particulars of Vessels of 6,450 Tons' Cargo Deadweight and 15 Knots' Speed.

	E. Original Vessel E, without Deep Tanks.	G. As Design E, but with Beam increased to obtain Proposed G.M. in Ballast Condition without Deep Tanks.	H. Vessel to Proposed Form to obtain Desired Stability in Loaded and Ballast Trim.
Length	550 ft.	550 ft.	550 ft.
Breadth	66 ft. 3 in.	68 ft. 3 in.	63 ft. * / 67 ft. 10 in. †
Depth	45 ft.	45 ft.	45 ft.
Hull	4,800 tons	8,570 tons	8,220 tons
Machinery	1,750 tons	1,730 tons	1,690 tons
Light ship	10,150 tons	10,300 tons	9,910 tons
Coal	2,450 tons	2,450 tons	2,370 tons
Fresh water and stores	1,450 tons	1,450 tons	1,450 tons
Cargo	6,450 tons	6,450 tons	6,450 tons
Displacement	20,500 tons	20,650 tons	20,180 tons
Shaft horse-power	9,000	8,850	8,700
Capacity for water ballast in double bottom	1,800 tons	1,800 tons	1,800 tons
G.M. in light condition	2 in.	1 ft. 2 in.	1 ft. 2 in.
G.M. with ballast tanks filled	1 ft. 9 in.	2 ft. 6 in.	2 ft. 6 in.
G.M. with tanks and bunkers filled	2 ft. 7 in.	3 ft. 4 in.	3 ft. 5 in.
G.M. loaded at start of voyage	2 ft. 7 in.	3 ft. 2 in.	1 ft. 2 in.
G.M. loaded at end of voyage	1·0 in.	1 ft. 7 in.	9 in.

NOTE.—The deficiency in G.M. in the arrival condition can be made up by adding water ballast.

* About load line. † Extreme.

[illegible] but these can be overcome as necessary by adding water ballast in the double bottom.

Vessel E represents the greatest extreme, but the deficiency in the ordinary ballast condition, or when oil or fresh water is carried in the double bottom, can be corrected by filling the deep tanks. Objection is sometimes raised to the fitting of such tanks however, since the most economical means of arranging for them gives an unhealthy system of subdivision, and, alternatively, if a rational system of bulkheads is adopted, the spaces necessary for such tanks would conduce to making the adjoining holds too short for the handling of long cargoes. In view of all the foregoing it is thought that further consideration should be given to developing forms which would better meet the desired conditions for such types of vessels, and it is suggested that if the form of vessel E were modified this desire could be obtained, and, at the same time, the cost and weight of the hull, propelling machinery and fuel would be reduced. It is proposed to reduce the breadth by 3 ft. 3 in. from about the load-line upwards, and from the load-line downwards to gradually increase [illegible] at the light water line. Table III, the basis of which is a fixed amount of cargo deadweight, gives the comparative particulars for (E) the original vessel E; (G) a vessel of similar design to (E), but 68 ft. 3 in. breadth, and (H) a vessel of the suggested form and dimensions. The extreme breadths for (G) and (H) have been fixed to give the [illegible] of G.M. in the ballast condition. It is estimated that the weight of hull (H) would be reduced by 180 tons compared with (E), due to the reduced width of the top-side structure, and also owing to the reduced displacement at the ends of the vessel. The extra width below the water-line amidships does not appreciably increase the weight, as the reduced scantling of the side frames due to their shape would counterbalance the extra material involved by the additional girth. It is estimated that the proposed underwater form of hull would not involve any additional expense over the ordinary straight form.

It is also estimated that the power necessary for a speed of 15 knots would be reduced by about 3½ per cent., due to redisposing the volume at the ends towards the underwater part amidships.

The writer is aware that there may be the three possible objections to this proposed modification of form, and these are :—

(1) The possibility of the vessel being damaged against a quay wall if the additional width when submerged is not known to the docking master.

(2) The Government authorities may demand an increased outreach of boat davits, but it is suggested that such increase would be unnecessary considering the gradual increase of the shape of the hull; also that the increased width would be below the water level in the ordinary seagoing condition.

(3) The theoretical floodable lengths would be somewhat reduced amidships.

It is suggested that if such a form were adopted it would be greatly to the advantage of owners in shifting a vessel when light; also to builders, considering that it is necessary to have considerable stiffness when fitting out, and the ordinary ballast tanks are not always available for this purpose during construction.

TABLE II.—THE INFLUENCE OF FORM UPON THE STABILITY AND PROPULSION OF PASSENGER SHIPS.

Stability Particulars for Various Types of Vessels.

Description.	A.		B.		C.		D.		E.		F.	
		G.M. by Proposed Formula.		G.M. by Proposed Formula.		G.M. by Proposed Formula.		G.M. by Proposed Formula.		G.M. by Proposed Formula.		G.M. by Proposed Formula.
Length	430'		470'		430'		440'		550'		500'	
Breadth	66'		56'		57'		56'		66' 3"		62'	
Depth	35'		40'		32'		38'		45'		39' 6"	
Draught (loaded)	28'		27' 6"		27'		26' 4"		28' 6"		23' 6"	
Block coefficient on loaded draught	0·73		0·71		0·65		0·66		0·69		0·52	
Light draught	11'		13'		13' 6"		13' 10"		16' 7"		19' 2"	
M.C. in light condition	4'	3' 6"	1'	3' 6"	6"	3' 6"	− 2"	3' 1"	+ 2"	3'	+ 10"	2' 7"
Weight of water ballast in double bottom	1,350 tons		900 tons		750 tons		960 tons		1,800 tons		1,000 tons	
M.C. in ballast trim	4' 11"	3' 1"	2' 9"	3' 2"	2' 3"	2' 11"	2'	2' 8"	1' 9"	2' 6"	2' 10"	2' 2"
Weight of water ballast in peak tanks	1,000 tons								2,100 tons			
M.C. in peak tank ballast	4' 2"	2' 6"							2' 10"	2' 2"		
Deadweight	1,250 tons coal		1,000 tons coal		1,900 tons coal		2,200 tons coal		2,450 tons coal		1,000 tons coal	
M.C. in light condition and fuel	2' 6"	2' 2"	1' 11"	2' 10"	2'	2' 3"	2' 8"	1' 9"	3' 10"	1' 6"	2' 1"	1' 11"
M.C. in light condition, fuel, water and light water in peak tanks	8"	8"	1' 3"	11"	1' 10"	1'	2' 4"	11"	2' 7"	1' 2"	2' 7"	1' 9"
M.C. in light condition with fuel, water and water in peak tanks	4' 9"	1'	4' 11"	1'	4' 7"	1' 8"	4' 3"	1' 8"	10"	1' 7"	1' 4"	2' 2"

NOTE.—Allowances have been made in the ballast and fully loaded conditions for free surface in fresh-water tanks.

The G.M.'s in these two loaded conditions are calculated on the assumption that the cargo spaces are filled with homogeneous cargo.

COASTAL MOTOR BOATS ("C.M.B.'s"): THEIR DESIGN, AND SERVICE, DURING THE WAR.*

By SIR J. E. THORNYCROFT, K.B.E., and LIEUT. BREMNER, R.N., D.S.O.

With the great increase in size of all torpedo-carrying vessels in the years preceding the War, it seemed that anything in the nature of the early small torpedo boats were things of the past. In recent years, with the exception of probably only the Italian Navy, surface vessels to fight with torpedoes have not been built which were less than 500 or 600 tons, and the torpedo-dropping gear with which picket boats were formerly fitted was in most cases scrapped. With the development of the internal-combustion motor as an alternative to steam machinery, at intervals since the Russo-Japanese war, some odd experimental torpedo boats of small size were built in this country and on the continent, but it was generally considered that they would be no more use than the early steam torpedo boats which were definitely weapons of the past. This conclusion was probably due to the fact that it was recognised what possibilities of high speed and increased radius of action petrol engines gave in comparison with the best of the old steam machinery. The war had not been long in progress before the idea of employing quite small motor torpedo boats was put forward, and during its course over 100 were built.

Early War Suggestions.

In the early summer of 1915, three officers, Lieutenants Hampden, Bremner, and Anson, suggested the possibility of utilising quite small motor boats to go over the mine fields and attack the German bases. After the suggestion had been tentatively approved, it was decided that to give any possibility of success, the boats complete with an 18-in. torpedo should not exceed the weight of the ordinary 30-ft. motor boats carried in the davits of the light cruisers. They should have a speed of not less than 30 knots when carrying the torpedo and a full load of fuel for a considerable radius of action. At first these conditions seemed almost impossible, as the high-speed racing boats, which they would necessarily closely follow in design, did not carry any greater load than their crew of two or three men and fuel only in sufficient quantity for a short race. They had never been designed with lifting gear and stiffening to enable them to be slung in davits with a heavy load. The limit of the weight had to be under $4\frac{1}{4}$ tons, of which the torpedo alone was about $\frac{3}{4}$ ton, but from available data concerning the particular high-speed motor boat which one of the author's firm had designed and built, and from fresh model experiments which were undertaken, it was felt to be pretty certain they could be fulfilled. This design was the result of many years of experiment by Sir John I. Thornycroft, the designer of the *Lightning*, Torpedo Boat No. 1 of the British Navy, who from his earliest days has always been interested in the design of boats which would skim on the surface. In 1910, he built *Miranda IV*, which would not only skim well on the surface of the water when driven at high speed, but also had good sea-going qualities.

Skimming Boats.

Before the war there had been a considerable development in skimming boats of various designs, following the proposals of the Rev. C. M. Ramus to construct the bottom of the hull in the form of a series of inclined planes so as to lift the hull by the reaction of the water on to the surface, but boats of rectangular section, such as he proposed, could not be good sea boats, and in rough water they slammed very badly. The successful design referred to had a form which was rather beamy with a single step formed by the fore body, which in itself took the form of a normal bow, but built with a sharp angle of chine running from the step to the stem. This sharp angle gives a lift not only in fore and aft direction, but in a lateral one as well, and by keeping a distinct rise of floor at all the sections, back to the step, a form is produced which does not slam unduly in rough water. Boats with hulls of this form can be made to skim satisfactorily when weighing as much as 45 lb. per h.p. After considering different dimensions it was concluded that it would be necessary to have a boat of 40 ft. in length to carry the torpedo and fulfil other requirements.

Weight Limitations.

While the condition was laid down that the total weight of boat and load should be less than $4\frac{1}{2}$ tons, in order to use the existing davits, there was the quite independent limit of weight within which the boat must be kept in order to give the speed performance of over 30 knots. The weight of the machinery which could be obtained for the power required, estimated at 250 h.p., was known, and the difference between this and $4\frac{1}{4}$ tons was available for the hull and torpedo gear, &c. It was obvious that no ordinary form of torpedo discharge gear could be used, as no margin of weight was available, and that the arrangements for carrying the torpedo must be incorporated in the structural hull of the boat itself. It was decided that, to be effective, the boat must be able to fire its torpedo while travelling at full speed. Any system of discharge over the bow was looked upon as unsatisfactory, not only from the point of view of good results from the torpedo, but also from the difficulty of carrying a torpedo in the fore part of the boat. It was obvious that the dropping gear was not to be used, and the ordinary tube was out of the question from the point of view of weight, so that the torpedo carried in a trough or half-shoot, the method adopted in the second-class torpedo boats built in the early eighties, would be the simplest and lightest arrangement.

Torpedo Carrying.

In view of the objections to carrying the torpedo in the bow, it was decided to build the after body of the boat to form a trough, with rails on which the torpedo would be carried on its side lugs, and to extend these rails beyond the stern of the boat so that the torpedo would drop clear when discharged. The obvious objection to carrying the torpedo in the stern, necessitating turning the boat away when attacking to bring the torpedo in the right direction to fire, would necessarily greatly reduce the chances of a successful attack and expose the boat to much greater risk of being hit by the enemy. It was, however, thought possible that, with the boat travelling at over 30 knots' speed, which would be approximately the same as that of the torpedo, it might be possible to discharge the torpedo from the stern of the boat tail instead of head first. Preliminary experiments were made, and the torpedo experts of the *Vernon* reported that they anticipated the results would be successful and, in view of this report, and that of the Director of Naval Construction, Admiral Sir Henry Jackson, who was the First Sea Lord at the time, gave the order for twelve boats to be built. To provide for the torpedo the above-water form of the stern had to be modified, and to make the boats as good

* Abstract of a Paper read at the Spring Meetings of the Sixty-fourth Session of the Institution of Naval Architects, March 21.

as possible for rough water the hull body was made less flat in the bottom than is usual for smooth water, the flatter form is better for speed but it is not so good when the water is rough. Experience with [illegible] racing boats had shown that it was not possible to make nearly so light a hull that would stand up in steel as in wood, and also that the timber construction must be elastic to a very high degree, that any knees or sawn timbers were invariably broken or pulled away from other parts of the structure, and that good results could only be obtained by using timbers of American elm, which would easily bend, and two or more skins of light planking. It will be noted that the construction which was adopted is almost identical to that which has since been carried out, on a lighter scale, in the most successful seaplanes. With such a very light construction the problem of attaching the sling plates to the boat to be carried in the ship was an interesting one. As the motor and the torpedo were a large proportion of the total weight it was decided that the best arrangement would be to take their weight as direct as possible on to the sling gear, and so it was attached primarily to the engine bearers in the boat, and to the rails of the torpedo trough in the stern. The torpedo trough was made to form a longitudinal girder in the after part, and the engine bearers a longitudinal girder in the fore part of the boat. From previous experiments with different forms of hull the builders were satisfied that the best form had been adopted, but model experiments were carried out with a number of alternative forms were tried. The diagram, above, of the relative performances of the different models shows how that contained. It was suggested that a V-bottomed flat stern boat without a step might have better sea-going qualities, as it would be less likely to slam in rough water, but the resistance curve showed that it would be impossible to get the required speed with such a form. It was thought that a hollow-bottom form might be suitable, and would have the advantage of showing less spray, but here again the resistance curve showed that the speed could not be so great, and with the peculiar form it was almost impossible to place the motors anywhere but in the after part of the boat, and this would make it very difficult to carry the torpedoes. This form of hull was also necessarily heavier for given dimensions. A 40-ft. boat of this design was, however, built, but it was never actually used in service. The hollow-bottom form of boat, as built in America and known as the Hickman Sea Sled, is fitted with semi-immersed propellers. These were also tried on what may be called the standard 40-ft. C.M.B.'s as well, and the hollow-bottom experimental boat was tried

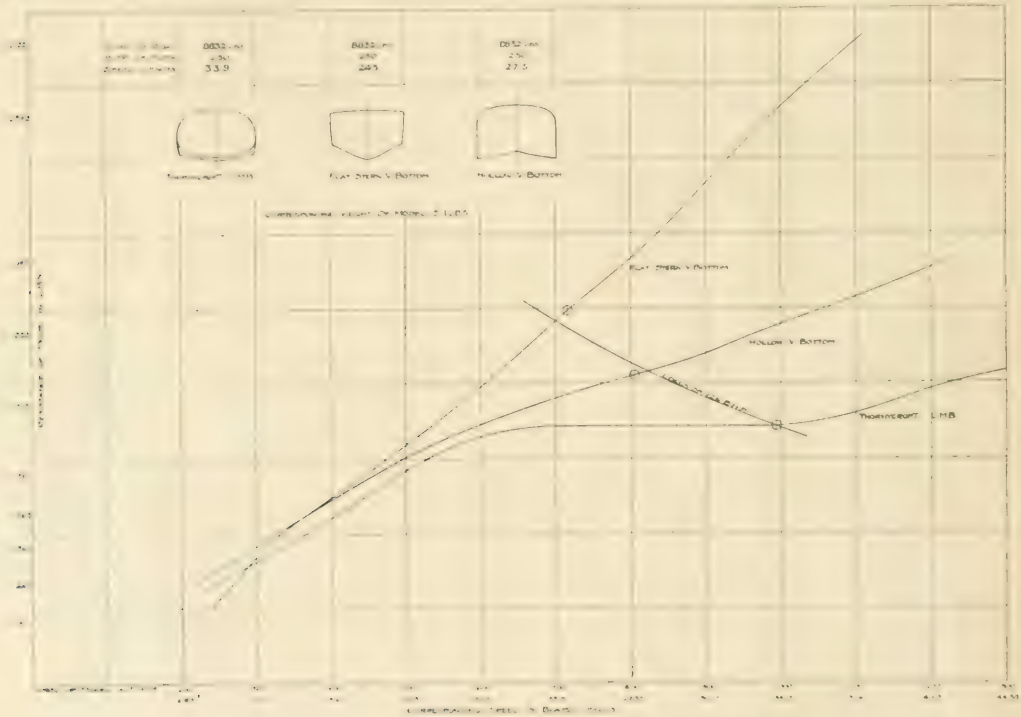
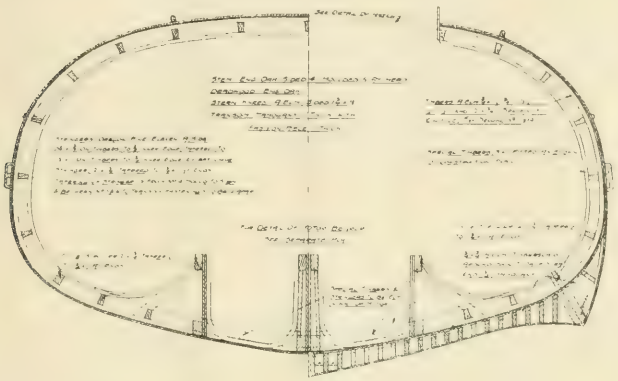


Diagram showing Relative Performances of Models with Different Hull Forms.

with exactly the same propellers and gear as the standard boats, so that every alternative arrangement was given a trial. The average speed of the first 40-footers, which was considerably improved upon in later boats, was 33·5 knots with 250 h.p., the screws having a pitch of 36 in., and a diameter of 22·5 in., the displacement with full load of fuel, crew, torpedo, and sea-going gear being 4·25 tons. With a skimming boat it is not easy to say exactly what the resistance is, and therefore, to claim a very high efficiency of the propeller, but there could be no doubt that it was very good. Besides the ordinary design a special form was used on some of the boats. The reason for adopting this form was the facility it gave to pass over obstructions such as wires and booms. It will be seen that it is not unlike some of the earliest screw propellers ever tried, and it is very remarkable that the efficiency was almost as good as the best propeller of normal type that could be designed.

The draught and 'midship section shows the details of the scantlings and how they were arranged to give the necessary strength to the hull. The fact of the trough for torpedoes cutting through the deck of all the after part of the boat made it necessary to tie the boat together in some other way. This was done by making the supports of the trough in a vertical plane act as cantilever girders to hold the deck and the top of the trough in position. It will be seen that the construction of the trough including the rails for the torpedoes was of wood, with the exception of the attachment for the ram impulse gear and the release gear, which was incorporated in the lifting attachment, and the wooden supporting rails were faced with bronze. The attachments for lifting the boat which consisted of hooks on either side of the torpedo trough, were carried down past it to the continuation of the engine bearers which formed the internal keelson, so that the weight of the torpedo on the rails was taken directly to the hooks as mentioned when referring to the lifting gear, and the hull of the boat might be considered to be carried from the attachment to the keelson. To discharge the torpedo satisfactorily it was found that a velocity of 25 ft. per second, about 17 knots, was sufficient, and assuming the boat was travelling at 30 knots, the torpedo would enter the water with the tail slightly down at a forward velocity of 13 knots. The impulse to push the torpedo out was given by a long-stroke ram, fitted with an aluminium cap, or "bell-head" as it was named, which was long enough to cover the firing pistol and bore of the torpedo head where the spherical end was near the full diameter. While at first it was doubted if the head would be stiff enough to take the thrust without buckling, it was found that by making the surface in contact about three inches wide, no deformation occurred. The bell-head was fitted with openings so that access was given to the firing pistol to withdraw the safety pin. It was at first thought that it would be best to operate the ram by compressed air, but it was found that the reservoirs would be too heavy, and so it was arranged to make the supply of high-pressure gas to operate it by burning cordite in an enclosed vessel at the moment the torpedo was to be fired.



'Midship Section of 40-ft. C.M.B., showing Scantlings.

Torpedo Discharge.

It has already been explained that the supporting rails were extended beyond the stern of the boat, and to avoid the possibility of the head of the torpedo or pistol striking the end of the trough or stern of the boat, the head of the torpedo was supported in a loose stirrup until it was clear of the rails, the stirrup, as soon as the torpedo was in the water, falling clear. The running of the torpedoes fired in this way was most satisfactory, the depth-keeping being found generally better than any other method of discharge. For travelling in the seaway, jambing screws were arranged to hold the torpedo tightly down on to the rails. Access was arranged through the bottom of the trough where necessary to get at the underside of the torpedo in case it had to remain in the trough for a long period, and for use in the winter arrangements were made to keep it warm by a connection from the exhaust of the engine.

Propelling Machinery.

To provide the 250 h.p. which was necessary, a weight of only 2,100 lb. was available, and meant the employment of motors which were very little heavier per h.p. than those for aeroplane use, but for work at sea there are many conditions which make a motor of the pure aeroplane type unsuitable. During the rush to provide boats quickly a certain number of motors designed for aeroplanes were used, but those which have proved really successful were designed specially for these boats, the 250-h.p. 12-cylinder V-pattern engines having cylinders of $5\frac{1}{4}$-in. by 7 in. They developed their power at 1,400 revs. The motors built for later boats were also V-pattern 12-cylinder engines, having cylinders of $5\frac{3}{4}$ in. by 7 in., which developed about 375 h.p. at 1,600 revs.; and weighed 2,600 lb. The first boats were not fitted with reversing gear, but the later twin-screw boats were so fitted on one engine, for manœuvring. The fuel capacity of the 40-ft. boats was 100 gallons, which gave a radius of 160 miles, and the 55-footers carried 350 gallons, which gave 200 miles, the difference in radius at full or reduced speed being not very great, as the resistance at a slow speed when the boats are not skimming is proportionately greater. The crews of the smaller boats consisted of two officers and one motor mechanic, and of the larger boats two officers, two motor mechanics and, in some cases, one wireless operator. The motors of the boats built during the war were not very effectively silenced, but those which have been built since have quite an efficient silencer. It is not easy to make the exhaust arrangements satisfactorily on boats of this type, and there is bound to be considerable relative motion between the motors and the sides of the boat; but very good results can be obtained by using water-jacketed flexible metallic piping and passing the exhaust through a silencer with a minimum of restriction, but in which water is made to mix with and cool the gases. The only objection to a silencer of this sort is that it necessitates special arrangements for controlling the water supply when it is desired to produce a smoke screen. For certain operations effective silencing of the motors is very desirable, but it was found, during the war, that the noise of the unsilenced exhaust was so similar to that of the aeroplane motors that the C.M.B.'s were mistaken for them, and so the noise was not so detrimental as at first had been anticipated.

Radius of Action.

A comparison between the radius of action and speed of these boats fitted with petrol engines and that of the early steam torpedo boats is of interest. The last second-class torpedo boats which were built to be carried on the mother-ship *Heckla* were 60 ft. in length, and carried one 14-in. torpedo. Their power was about 250 h.p., and they gave a speed of about 16 knots. Their fuel capacity was nominally sufficient for three hours' full speed, but the difficulty of firing the boilers in a choppy sea was very great, and it was recognised as impossible to make a long run and be in condition to make an attack at the end. Assuming they did their nominal performance, the 40-ft. C.M.B. does twice the speed and carries a torpedo of more than double the power.

A comparison of the weights of rather earlier second-class boats, which carried two 14-in. torpedoes in troughs, with those of the 55-ft. C.M.B.'s is given in the following table :—

	Second-class Torpedo Boat, 1880–1890	C.M.B., 1915–1920
Length	63 ft. 9 in.	55 ft. 0 in.
Beam	7 ft. 6 in.	11 ft. 0 in.
Speed, corrected trial	17·3 knots	40·4 knots
Speed, service [illegible]	15 knots	38 knots
H.P.	170	750
Displacement.		
Hull, Fittings and Torpedo Gear	5·16 tons	5·5 tons
Machinery, including fuel tanks and [illegible] in C.M.B.	5·36 tons	4·1 tons
Armament, [illegible]	0·8 (14 in.)	1·27 (18 in)
Fuel	1·00 tons*	0·97 tons†
Crew	0·57 (8)	0·36 (5)
	12·89 tons	12·20 tons

* Fuel sufficient for 4 hours' steaming. † Fuel sufficient for 5 hours' steaming.

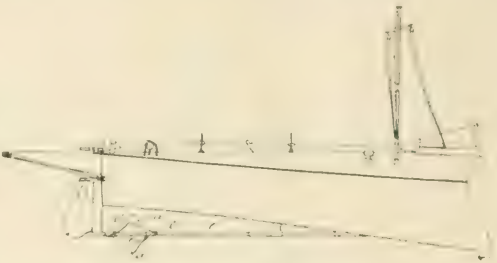
Lifting Arrangements.

It has been explained that the original intention was to carry the 40-ft. boats in the davits of the light cruisers, and a number of them were used in this way. The larger 55-ft. boats were never intended to be used with a parent ship. It was, however, recognised that, if they were to be

Photograph of Special Propeller fitted to C.M.B. for passing over Obstructions.

in the best condition for service, they should be only in the water when in use, and they were therefore designed with a view to being lifted out frequently at the various bases. It was decided that the best way to sling these larger boats would be by using slings of sword matting, or similar material, attached to a beam of about the length of the boat fitted with spreaders. This arrangement proved very satisfactory, and the boats were readily lifted in and out of the water without any straining. At some of the bases where it was not convenient to provide cranes or lifting gear, slipways were provided which were effective, but of course, not nearly so quick in operation as the crane, and there was always some risk of damaging the shafting or propellers in putting the boat on to the cradle. The danger of freezing up had to be guarded against, and special precautions were, of course, necessary in boats carrying large quantities of petrol, which prevented the use of open fires. In many ways the difficulties [illegible] the maintenance and running of these craft were similar to those encountered with aeroplanes. The most successful seaplanes have now adopted a form of hull and construction very similar indeed to the C.M.B.'s, and are being fitted with a special engine and water propeller for surface running as well as their air propeller for flying.

Some people argue that, with such a combination there is no longer a field for a pure surface boat of the C.M.B. type, and it cannot be denied that the advantage of being able to take to the air, by adding wings to your boat, must be very great; but, on the other hand, the authors believe that it will be found there is a field for the C.M.B. as well as the amphibian. The flying boat is necessarily much more liable to damage owing to the size of its wings, and all the structure as well as the motor being much more highly stressed. The most successful flying motors are not expected to run



Elevation of Stern of C.M.B., showing Special Propeller.

much more than 150 hours without being completely dismantled and overhauled, but the motors used in the C.M.B's are run so much more easily that it is not necessary to overhaul them for several hundred hours at full power.

It has been explained that when the proposal to use C.M.B.'s was first made it was intended that they should be used to attack the enemy bases in the North Sea, that they should be carried by light cruisers and lowered when the mine-fields prevented the cruisers going any farther. It was not possible to carry more than two boats on each cruiser, and the advisability of fitting out a special carrying vessel or mother-ship which could take six at once was considered. It was not found possible to appropriate a vessel until the latter part of the war, when the cruiser *Diamond* was fitted out and took six 40-footers to the Mediterranean. While they were carried by the light cruisers as originally proposed, no serious attacks were made on the German bases, and the first boats built were sent to operate on the Belgian coast with Dunkirk as an advanced base. Other bases were organised at Dover Portsmouth, Osea Island, and Portland. The first success was obtained with the boats operating from Dunkirk early in 1917, when four of them, under the command of Lieutenant Beckett, attacked German destroyers off Ostend, sinking one and scoring several other hits. Largely as a result of this successful operation, more boats were ordered, including twin-screw 55-ft. boats, an experimental one having already been built. Captain Walwyn, of the Anti-Submarine Department, suggested the employment of these 55-ft. boats, carrying a single torpedo and four depth-charges, for anti-submarine work, and a great deal of patrol work was eventually done from all the bases, with these 55-footers. Owing to their larger dimensions they were, of course, better sea boats than the 40-footers, and in the Channel and on the Belgian coast largely replaced them. The boats patrolled the Belgian coast inside the sands, and were able to keep a constant watch on Ostend and Zeebrugge. On one occasion, when five German destroyers attempted to dash through the Straits, C.M.B's met them on their return and succeeded in torpedoing one of them.

THE POWERING OF MOTORSHIPS.*

By K. C. BARNABY, B.Sc.

In this period of depression, the motorship occupies a very special position, to which it would not easily have attained in more prosperous times. Both owners and builders are looking to it, not with the mistrust that is usually accorded to new things, but with the eyes of hope and as a means of salvation. The owner is searching for a more economical ship that will enable him to compete favourably with less progressive rivals. The builder knows that almost his only chance of obtaining orders is to offer something that will give

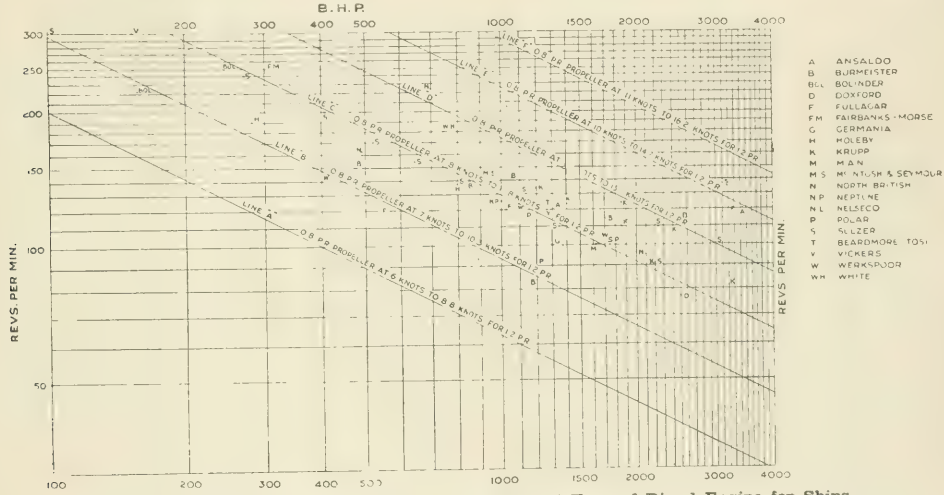


Fig. 2.—Test Diagram for Determining Suitability of Type of Diesel Engine for Ships.

very marked and peculiar advantages over existing tonnage. These feelings, together with the great success of so many motorships, and helped by the prominence given to some geared turbine failures, have combined to shed a veritable halo over the marine oil engine.

Suitability of the Diesel Engine.

Nor does the perusal of the energetic periodicals that are devoted to pushing motorships lead one to suppose that under any conceivable circumstances could a Diesel (for simplicity of language the term "Diesel" will be used to cover any type of marine engine burning heavy oil) fail to show immense advantages. Should the boiler of a tug-boat explode, the incident is described as "a somewhat frequent occurrence with steam plant" (*sic*), and the moral is at once drawn that no such accident has yet been recorded on a Diesel tug. This is all very well, but it will be exceedingly unfortunate if it leads to fitting Diesel engines under unsuitable conditions. The resulting failure, or partial failure, can only tend to retard progress. As an illustration—an admittedly extreme one—of the danger of fitting a radically unsuitable engine, consider the following case. A small single-screw cargo steamer is employed on a coasting service in the tropics. She is 220 ft. b.p. by 33 ft. beam, displaces 2,440 tons on a load draught of 15 ft. 6 in., and steams 9 knots with 650 i.h.p. It is desired to replace the steam machinery by a Diesel, and the stock engine offered is rated at 675 i.h.p. at 155 r.p.m. It might be rashly assumed at first sight that the steam engine could be replaced by this motor and a somewhat similar speed be obtained, but on examination it will be found that this is far from being the case. The available shaft horse-power of the steam engine based on its probable mechanical efficiency is 520. The mechanical efficiency of this type of Diesel would be about 72 per cent., giving a shaft horse power of 485. In the Tropics we lose another 5 per cent. to 10 per cent., so that unless we resort to the undesirable practice of running under continuous overload our shaft horse-power is further reduced to, say, 440. Thus, if the propellers were equally efficient we should have lost nearly half a knot. But the old screw turned at 66 r.p.m., and had an efficiency of about 64 per cent.

Steam *versus* Diesel.

The Diesel, on the other hand, running at 155 r.p.m., assuming the same wake value of 30 per cent., would require a propeller with a pitch-ratio as low as 0·7. The propeller efficiency may be put at 52 per cent., and the speed of the ship at about 7¾ knots. The change from steam to an apparently more powerful Diesel thus leads to a loss of a knot and a quarter, or 14 per cent. in speed.

Now take the case of a passenger and cargo boat of about 9,000 tons displacement and designed to make 14 knots. The machinery is to be twin screw of about 5,000 s.h.p., and enough fuel is to be carried for a round voyage of 5,500 miles. The standard Diesel engines for this total power would run at about 90-115 r.p.m., so that a good propeller efficiency can be obtained, and one quite equal to that with any steam plant. The shaft horse-power will therefore be the same, and the Diesel fuel consumption can be put at 0·42 lb. per s.h.p. hour, against 1·1 lb. for oil—fuel, and double-reduction geared turbines. This means that the Diesel ship will consume nearly 600 tons

* Paper read at the Spring Meetings of the Sixty-fourth Session of the Institution of Naval Architects, March 22

[illegible] the engine will carry over 500 tons more cargo [illegible] allowing for the extra greater weight of the machinery. [illegible] the amount of cargo is fixed the Diesel ship can be made smaller and faster with less power. The economy will [illegible] be still more marked as the first cost will be about the same [illegible] and fuel costs not much more than half, even when allowing for a more expensive grade of oil. So in the latter case there is a clear gain with Diesel machinery, and in the former an equally clear loss. Apart from questions of reliability and maintenance, &c., that are outside the scope of this paper, the real criterion is that of propeller efficiency.

Propeller Efficiency.

Unless this be similar to steam practice, the best oil engine in the world may be less suitable than a relatively extravagant steam engine. In any case, it cannot show to full advantage, as fuel economy is after all the *raison d'être* of the Diesel, and on this it must stand or fall. For cargo boats this question of propeller efficiency is particularly important. Reciprocating engines are cheap, and have set an extraordinarily high standard of reliability. If coal is cheap and oil dear, the margin in favour of the Diesel is relatively small and must not be further whittled away by an inefficient screw.

The diagram on p. 149 is an attempt to produce a diagram that will show at a glance whether a particular engine is suitable or not for any proposed ship. It is based on the following data:—

Propellers for motorships have usually four narrow blades and their efficiency is about as shown in Fig. 1, always providing that the pitch ratio is the best possible for the conditions (see Note "A" in Appendix). Below 0·8 pitch ratio the efficiency becomes too low for ordinary purposes. Above 1·2 pitch ratio, though the efficiency is still improving, the Diesel has become unnecessarily heavy and should be speeded up. These values will therefore form approximate limits of suitability. The problem is, then, to connect these limits with power and revolutions for various speeds of advance.

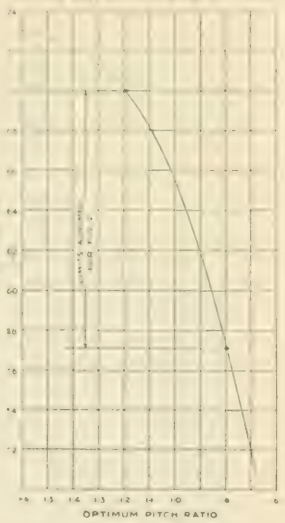


Fig. 1.—Efficiency for Typical Diesel Propellers where Best Proportions are Adopted.

Taylor's Propeller Charts.

Fortunately whatever method or elaborations or exact niceties of design are employed in calculating the propeller, we cannot get far away from a certain basic relation between these quantities, that will remain comparatively unaffected. Thus Taylor's propeller charts are based on a function, p = r.p.m. $\times \sqrt{\text{s.h.p.}} \div V_a^{2.5}$, where V_a = speed of advance of screw. The constants in Mr. S. W. Barnaby's tables are inter-connected by the "Wingfield Value" K, which = i.h.p. $\times R^2 \div V^3$, [illegible] = about 1·170. Powers again are connected by a relationship that can be reduced to the inverse of p or K, and on these values, in whatever form they may be put, depends the optimum pitch ratio that can be employed. Assuming, then, that we can adopt this optimum pitch ratio, or, in other words, that we can work the given screw at its best slip, we can write, Revolutions = Constant $\times V a^{2.5} \div \sqrt{\text{s.h.p.}}$ Put into logarithmic form, it becomes log r.p.m. = Constant + 2·5 log $Va - \frac{1}{2}$ log s.h.p., and is the equation to a straight line, as in the diagram on page 153. Here the lines represent the revolutions corresponding to any given power when a screw of 0·8 pitch-ratio is working at its best efficiency and advancing at speeds of 6, 7, 8, &c., knots.

The Diagram Explained.

But any line represents equally well any other pitch-ratio screw which is advancing at a speed corresponding to its best efficiency for the power. As 1·2 pitch-ratio was taken as our upper limit, the speeds of advance for this ratio have been calculated as shown in the diagram. Thus line "A" represents the relationship between power and revolutions per minute when a 0·8 pitch-ratio screw is advancing at 6 knots, or a 1·2 pitch-ratio at 8·8 knots, or of course intermediate values. Any engine which falls on this line, such as a 400 s.h.p. at 100 r.p.m., will then be suitable for ships that require this power for speeds of advance between 6 and 8·8 knots. Line "B" is suitable for ships with speeds of advance between 7 and 10·3 knots, and so on. The revolutions are roughly correct for screw with four narrow blades. Changes in area, &c., will, of course, affect them, but not enough to matter, seeing that the diagram is not intended for actual propeller design, but only to indicate the approximate limits within which a good one can be designed. The revolutions have been worked out from the curve of "K" values given in S. W. Barnaby's "Marine Propellers," 1921 edition. Before using the diagram it is, of course, essential to estimate the wake speed and deduct it from the speed of ship, so as to get the speed of advance on which it is based. For this purpose we can use Taylor's equations based on information supplied by Mr. W. J. Luke. While it cannot, of course, be strictly accurate to base wake value on block coefficient alone, it gives a close enough approximation for ordinary purposes. As motor screws are usually relatively small in diameter, single screws are likely to be operating in rather stronger wake than indicated, and twin screws, if they have big clearances, in a rather weaker one.

On examining Fig. 2 it will be noticed that the Sulzer range very closely follows line "C," except in the larger powers, and is beautifully graded for propeller efficiency. It is also clear that with this make it is usually immaterial if the machinery is single or twin screw. Thus the 800-b.h.p. model or two 410-b.h.p. engines are equally suitable for the same pitch-ratio, and give the same efficiency. Another point is that for the medium-power Sulzers, the best pitch-ratio is usually about one-tenth of the speed of advance.

Types of Engines and Characteristics.

It will be noticed that the only engines plotting below line "B" are the long stroke Burmeister and Wain, a Werkspoor, and a Fullager, and these are all close to it. With the makes of oil engines at present on the market, it can therefore be definitely said for reasonable propulsive efficiency, no ship should be designed with direct transmission for a less speed of advance than about 7 knots. The upper limit will be about 15 knots, above which the standard engine becomes unduly heavy and should be speeded up. The range of Diesels in actual service, or manufacture, will be seen to be suitable for all cargo boats of any size or power, provided they are designed for not less than about 10 knots' sea speed. The engines are also very suitable for intermediate mail and passenger boats. For the fastest types the regular engines are a little slow. It will be noticed that the big Ansaldo and Sulzers are relatively faster running. This is as it should be for ships of 17-18 knots, like the new 20,000-ton Fairfield-Sulzer liner building for the New Zealand Shipping Company. There are, of course, very many highly successful motorships of less than 10 knots'

speed, but in these cases the poor propulsive efficiency is masked by the extraordinary economy of the engine. All that is claimed on this point is that if the ship is under about 10 knots the propeller efficiency will be poor, and the Diesel cannot possibly show its full economy. Where there are special circumstances enabling full advantage to be taken of the reduced "standby" losses of a Diesel, it will pay to accept a reduced efficiency, and the 10-knot limit does not apply. Such cases are auxiliary sailing vessels, tugs, ferries on an intermittent service, and so on. With steam tugs of 300-500 i.h.p., for example, the revolutions would usually be round about 130, where as similar power Diesels would average 175-250 r.p.m. As the actual working hours of most tugs are few, it will usually be more economical to install the more powerful Diesel that is required to give the same towing and manœuvring powers as with a slower and larger steamdriven screw.

Suitability of the Diesel.

For vessels such as fire floats, &c., the Diesel is also clearly indicated as much the most suitable type. It may be argued that the revolutions of a Diesel can be altered in the same way that the designer of a steam plant will adjust the revolutions per minute of his engine to suit the speed of ship. Thus a reciprocating engine of 2,500 i.h.p. for a cargo boat might run at 70 r.p.m., and one of the same power for a torpedo-boat at 400 r.p.m. There is certainly some latitude, particularly in the way of increasing the revolutions per minute, but not so much as with reciprocating steam engines. Moreover, the latter are so standardised that almost any firm can be relied on to design a good example of the type. This is very different with Diesels, where any new type or even alteration calls for more or less elaborate experiments. Probably in the course of time this will change, but at present the shipowner should go carefully and adopt standard and well-tried types. The test-bed and not the high seas is the proper place for experiment. Reduction gearing, whether mechanical or electrical, will, of course, overcome the propeller difficulty. As the ratio of reduction need only be small, and nothing like as great as with turbine jobs, a single-reduction mechanical gear would usually seem the best solution as being the simplest and cheapest. At any rate it seems better suited for the small and slow cargo-boats that in general are the vessels that stand most in need of gearing.

Electric Transmission.

For the largest and fastest ships there can be no possible case for electric transmission on the ground of improved propeller efficiency. For instance, as deduced from the diagram, that for the new Fairfield-Sulzer liner already referred to will be exceedingly good, and could hardly be improved on. The advocates of electric propulsion should base their claims on the securing of lighter and simpler Diesels of a faster running and irreversible type, with greatly improved manœuvring powers. Here they are on more solid ground, the Diesel, though not so bad as the absolutely irreversible turbine and requiring a separate astern engine, is not inherently a good reverser. The type of pilot who is continually calling for touches ahead and touches astern is apt to be ringing down for a fresh order before the old one is executed. So that the idea of a single master switch that will control the whole vessel has undoubted attractions, especially where several units are involved. The proposal, though seriously mooted in some quarters, that such a master switch could be located on the bridge is more fanciful than practical. The Scotch engineer who would allow an inferior being, such as a mere deck hand, or even an officer, to control his cherished engine has yet to be found. For double-ended ferries electric propulsion is especially valuable in enabling all, or almost all, the power to be concentrated on to the aft screw, and thus avoiding the inefficiency of a driving bow propeller. The elimination of so much shafting that is often claimed as one of the advantages of electric propulsion is a rather illusory one.

Broken Stowage.

If the Diesel engines are amidships and the motors aft, with a narrow tunnel for carrying the cables and for communication, this will cause almost as much broken stowage as the usual wide tunnel, since the height will be much the same. If, on the other hand, the tunnel is abolished and the cables led along or under the deck, this divides the engine room into two separate sections, with resulting difficulties in efficient supervision. It is only in special cases such as small cargo boats, tankers, or ore-carriers that it is usually possible to arrange all the machinery aft owing to difficulties of trim. The habit of certain makers of rating their engines in independent horse-power has already been mentioned. Unfortunately the mechanical efficiency of Diesels varies immensely, according to the auxiliaries that are directly or independently driven. Thus sister ships may have engines of the same make, cylinder dimensions, revolutions per minute and independent horse-power, but which differ by fully 10 per cent. in actual or useful output. It would seem very desirable to quote powers in brake horse-power.

Single or Twin Screw.

As regards the fitting of single- or twin-screw machinery, the diagram on page 152 will serve as a general guide both as to the engines that are available for a given power and the probable propulsive efficiency. Strictly speaking, there are, of course, many other considerations than propeller efficiency alone in comparing single with twin screws. In practice, however, the increased resistance of the twin-screw bossings or struts, together with the rather greater hull efficiency of single screws is usually just about offset by the loss in propeller efficiency of the latter due to the slower speed of advance. In ordinary cases we can therefore compare single with twin screws by taking a speed of advance appropriate to the latter and finding the efficiency on this basis. This will be sufficiently close for practical purposes, as no one would fit twin screws with their extra expense and complications if there were only a minute saving in efficiency. It is often advocated that propellers for Diesels should be designed to absorb the full power at just under the normal revolutions per minute. This, except for auxiliaries, boats usually travelling half their time in ballast, or engines that are extravagantly fast, seems hardly desirable. It means that the engine will never reach its rated revolutions per minute unless overloaded. When turning at, say, 15 revolutions less than normal, it will really be working just as hard, as the bearing pressures will be identical, if not greater. In order to ensure long life it should be possible to run the engine at full rated speed, and then to deliberately ease it down to a slightly lower service speed. It will then be running under quite different conditions than when forced down to the lower speed by an over-large propeller.

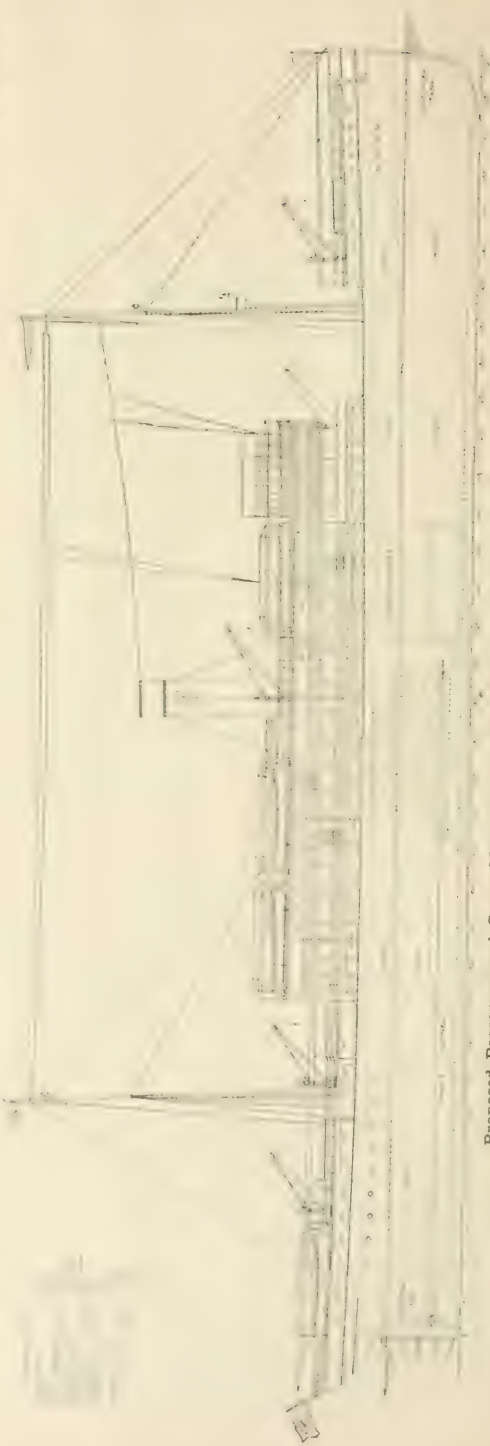
Conditions in the Tropics.

This is particularly important in the Tropics, where the conditions are especially severe, and there is a serious loss of power amounting to from 5 per cent. to 10 per cent. With regard to this loss, trial reports have been issued apparently denying it, as they purport to show a normal or even slightly greater output, under tropical conditions. But what this really means is that the engine will develop considerably more than its rated power in a cold climate, and the margin is enough to cover the less favourable circumstances of a hot sea and a superheated atmosphere. Steam engines suffer, of course, in the same way, but not to such a great extent in the case of reciprocating engines. Experience gained with many different makes and sizes of engines for boats of the Costeira Company has shown it to be absolutely essential to allow for this reduction in power. It applies not only to Diesels, but to hot bulb engines, petrol motors, and in fact all internal combustion engines. The boats of this company operate mainly within the Tropics, and emphatically the engines do *not*

develop their rated power at their rated speed. Incidentally this enterprising Brazilian concern is in perhaps the unique position of designing, building, and operating its own motor ships. One of these is the new twin-screw motorship *Itapassoca*. She has two 520 b.h.p. Sulzer Diesels, which are expected to deliver a total of 925 b.h.p. in service and give about 10 knots.

Opposite is a proposed design for the same company, the rather unconventional appearance is partly due to the necessity of keeping the principal cabins, saloon, &c., away from the ship's side. Running north or south in the Tropics, is not so bad, as the sun is on alternate sides of the vessel morning and evening. Though the wise traveller is found on the port side going south, and *vice versa* returning, his cabin, will then get the morning sun alone, and be fairly cool by evening. Steaming east or west is very different, as the sun, being on the same side all day, turns unshaded cabins into little purgatories. Diesels are especially suitable in the Tropics, as ensuring a cool engine-room, while the elimination of boiler uptakes or casings, coal shutes, &c., enable improved passenger accommodation to be arranged. One hesitates to say anything that would add to the burden of a naval architect's life, yet owners who are ordering new passenger ships would do well to insist on seeing a curve showing the range of stability rather than figures for initial G.M. in various conditions. The ever-increasing superstructure of modern ships on practically the same load draught means that the C.G. tends to become higher and higher in relation to the water surface. Now the higher this is, the more difficult it is to turn out a really good sea boat. It is easy enough by increasing the beam to get any desired initial G.M. without the use of water ballast. The trouble is to obtain a satisfactory righting lever at a considerable angle of heel without an excessive initial G.M. The necessity for this has been well brought out in recent papers before the Institution by Sir John Biles and Mr. Wall. A case has been worked out in the Appendix (Note B) to show that a low C.G. ship may have a small G.M. and be comfortable, yet absolutely safe from capsizing in any storm. While a similar ship with higher C.G. and a big initial G.M. may be not only uncomfortable, but even unsafe in heavy weather. Perhaps the author ought to apologise for bringing forward this very self-evident matter. He ventures to do so because, outside technical circles, there is such a widespread idea that G.M. *per se* is the proper measure of a ship's safety, whereas what it really indicates more than anything else is the probable amount of sea-sickness among the passengers. This is very necessary to know, but it is a part and not the whole, of the problem.

Probably a majority of those who are accustomed to the sea will agree that a narrow-beamed old-timer, with low superstructures, or a present-day "intermediate," is often a better sea boat than a modern "last word" liner, with her high sides and decks. The claims of suitable lines for comfort at sea, minimum resistance, and minimum weight are sometimes rather conflicting. An attempt has been made to combine the two former by "bulges," as in the *Cap Polonio*. This solution is not altogether desirable as it is costly, and calls for many outlet pipes to be carried through two hulls and made tight in each. It, of course, makes boat lowering in a seaway more dangerous than ever. If bulges are to become popular it will be interesting to see what attitude the Classification Societies adopt towards them. Motor passenger ships are especially suitable for working with a fine initial G.M., as the comparatively small amount of fuel can be easily compensated for by admitting water ballast. At any rate, they are better off than coal burners, with a necessarily large change in C.G. during the voyage. When calculating the power for a new Diesel ship the designer usually has a somewhat similar steamer to guide him. By correcting for the differences in mechanical and propulsive efficiency he can arrive at a fairly close estimate. The margin of trial speed over sea speed need not, however, be so great as with a coal-fired ship. The latter usually never again obtains her trial speed when



Proposed Passenger and Cargo Motorship for the Companhia Nacional de Navegação Costeira.

once handed over. The oil engine seems less susceptible to the expert handling of "trial parties," and owing to initial stiffness often improves in power after several months' careful running. Where there are no available data for a similar steamer, and in the absence of a tank, one may have to rely on an independent estimate of power. Here Admiral Taylor's charts are often of very considerable assistance, but they must be handled with great caution. It is obvious that they cannot be used for types greatly differing from the parent form. For instance, if used for a destroyer they would immensely overestimate the power. Similarly, for a small yacht there would be a nearly equal under-estimate. It is therefore a matter of interest to know where to draw the line, and with this object the author has examined several hundreds of cases. The results can hardly be dealt with here, but the general conclusion is that for the faster cargo boats, and for intermediate mail and passenger boats of fair size, they give astonishingly accurate estimates. For all other types, and particularly for small craft, they could not be relied on at all. What it means is that, for the former types, the lines usually closely approximate to those experimented on, whereas in the latter instances they do not. Where useless for absolute results, the charts, however, are often of service in estimating the effect of slight changes. When consulting these charts and other published tank records to find the nearest approach to a proposed design, there is at once the old difficulty of the difference of English and American methods in recording results. Both systems have special advantages. The Froude Constant method gives the whole power at once, and as it is practically the Admiralty coefficient inverted, is familiar and easy of handling. The American method of plotting residuary resistance separately in "lb. per ton of displacement" is more convenient when examining the effect of changing dimensions.

It also avoids some of the confusion due to various experiment tanks using slightly different frictional coefficients. Personally, the author finds it convenient to record his private data in a modified form by splitting up C into two parts. These correspond to the frictional and the residuary horse-power. That is, $C = C_f + C_R$, where $C_F = 427 \cdot 1$ f.h.p. $\div \Delta^{2/3} V^3$, and $C_R = 427 \cdot 1$ r.h.p. $\div \Delta^{2/3} V^3$. F.H.P. and R.H.P. denoting the frictional and residuary parts of the total E.H.P.

The relation between C_R and Taylor's residual resistance per ton ("R*r*") is then simple, viz., $C_R = 1 \cdot 311 \, Rr \, \Delta^{1/3} \div V^2$. C_F can be taken from a diagram, such as that in Mr. J. L. Kent's 1915 paper. This notation has the great advantage of showing at a glance the proportion of residuary to frictional resistance, and thus gives a better idea of the efficiency, possibilities, and character of the design than a single C alone.

The residuary is, after all, the only part over which the naval architect has jurisdiction. This, by alteration in form, he can vary within wide limits, and it is from this variation that the economic success or failure of the hull design mainly depends. Anything that tends to illuminate this controllable part of the effective horse-power is therefore to be encouraged.

Checking E.H.P. by Actual Model.

For those who, like the author, are exiled far from experiment tanks it may still be advisable to check the effective horse-power by actual trial of a model. A convenient arrangement which eliminates the use of dynamometers is to tow against a standard model. This may have been originally obtained from a tank, or else made from lines of which one has the accurate effective horse-power (such as Taylor's standard series). The models of about the same size are towed on opposite sides of a launch, and the towing cords connected to a point on a light pivoted lever (see Fig. 3). The cords and lever (which can be replaced by a third cord if desired) set themselves, of course, to the force diagram existing at the instant. The angle of the lever from the centre line is then a measure of the amount by which the resistance of the new model is greater or less than the known one. The arc swept out by the lever tip can be easily graduated to read in percentages of the effective horse-power. Those on the new model side being of course greater, and those on the old model side less than that of the latter. This method is likely to be more accurate than towing against a dynamometer in open water. It largely eliminates the effect of slight unknown currents, which affect the models equally if they are of the same length. Given this, and a constant percentage difference, the current effect is completely eliminated. In any case a 10 per cent. error is not 10 per cent. of the total effective horse-power, as when towing against a dynamometer, but 10 per cent. of the percentage difference. If the latter is 5 per cent., the error becomes about $\frac{1}{2}$ per cent., a different matter. The table on page 154 gives a list of existing motorships with particulars compiled from the published information available. In conclusion, the author desires to thank the Costeira Company for kindly according him permission to include a drawing of their proposed new vessel.

APPENDIX.

Approximate Dimensions of Typical Motorships.

Note A.—These efficiency values may seem low, especially for the smaller pitch ratios, when compared with the figures given by Taylor or Froude. But these ultra-fine screws are usually also of small diameter on motorships. This leads to manufacturing difficulties, and it is hard to maintain the proper pitch at the root, even if there is no overlapping of blades.

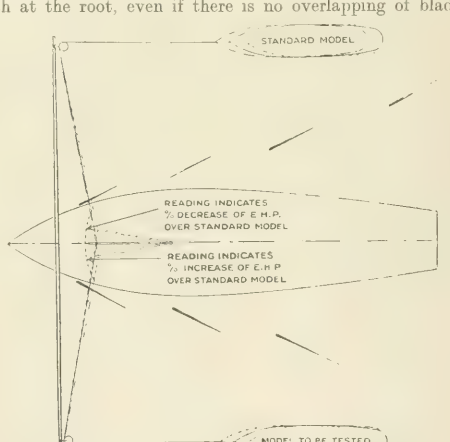


Fig. 3.—Method of Checking E.H.P. by Towing an Actual Model.

Probably the efficiencies can be improved on with fairly large diameter screws, though those given may be taken to represent average results.

Note B.—Consider three ships of similar length and displacement, and with a common draught of 20 ft. Ship "A" has a C.G. 19 ft. above the keel; "B," 20 ft., and "C" 21 ft. The initial G.M. of ship "B" is 1 ft., and the righting lever at 30 deg. is 0·5 ft. The beam of ship "A" is narrowed to give an initial G.M. of 0·5 ft., and that of ship "C" broadened to give 2 ft. This results in changing the righting arms at 30 deg. to 0·4 and 0·6 ft. respectively when calculated for a C.G. in the load water plane. But at 30 deg. we have to add on 1·0 sin 30 deg. for case A, and deduct 1·0 sin 30 deg. for case "C." The actual righting arms are therefore 0·9 ft. for ship "A," and 0·1 ft. only for ship "C." Ship "A" is therefore not only comfortable but safe. Ship "C" is less comfortable, and despite its considerable initial G.M. unsafe in squalls.

Approximate Dimensions of Typical Motorships. (See page 153)

No.	Name	Built	Length (B.P.)	Beam	Draught	Displacement (or D.W. Capacity)	Power (B.H.P.)	Speed (Loaded)	Type of Engine	R.P.M.	Single or Twin Screw
1	[illegible]	1922	105	19	7 27	1·62	370	12 61	Kromhout	311	T
2	[illegible]	1921	114	20	9 7	600	180	8·5	Kromhout	280	S
3	[illegible]	1913	115	21 5	9·7	3,000 D.W.	220	9	Beardmore		S
4	[illegible]	1921	125	24 6	10·75	740	180	7·5	Kromhout	300	S
5	[illegible]	1913	149·2	24 5	9 8	780	350	8 9	Beardmore	250	S
6	[illegible]	1920	160	23·75	11 3	500 D.W.	500	10	Fullagar	110	S
7	[illegible]		165	29 7	13·45	6,500 D.W.	160	6 5	M.A.N.		S
8	[illegible]	1913	166 7	28 2	11·83	1,000	250	8·0	Polar	145	S
9	[illegible]	1876–1921	188	30	15·1	1,500 D.W.	320	7·5	Polar	250	T
10	[illegible]	1910	196	37·75	13·2	2,080	480	8·0	Workspoor	180	S
11	[illegible]	1918	198·7	31 2	13		1,650	14·0	Polar	165	T
12	[illegible]		210	39	23 5	1,9500 D.W.	600	7·7	Wilton		
13	[illegible]	1907–1922	211	37	8·2	1,380	360	7·0	Kromhout	300	T
14	[illegible]	1922	215	34 5	14·5	2,275	730	10·0	B. & W.	125	S
15	[illegible]	1922	240	38	17 5	3,500	1,250	11·0	B. & W.	120	S
16	[illegible]	1912–1921	248	42 1		3,525	1,000	10·0	M. & S.	180	T
17	[illegible]	1891–1918	249	37·5	19·7	3,600	530	7·0	Sulzer	240	T
18	[illegible]	1912	258	45	18 1	4,300	1,100	10·0	Werkspoor	125	S
19	[illegible]	1916	270	37·7		2,000 D.W.	1,000	11·0	Werkspoor	120	S
20	[illegible]	1922	273·6	41	17·5	2,7500 D.W.	1,000	10[illegible]	Polar	150	T
21	[illegible]	1912	276	40·5	17·8	4,360	770	8·75	Carels	90	S
22	[illegible]	1914	280	39	18·25	4,060	1,500	12	Vickers	150	T
23	[illegible]	1922	280	43·5	17·5	4,050	1,000	11	N. British	105	T
24	[illegible]	1923	288	43·0	15	4,000	1,040	10	Sulzer	170	T
25	Erland	1922	292	43·0	19·75	3,500 D.W.	1,200	10·5	B. & W.	95	S
26	[illegible]	1921	299 5	44·0	22	6,350	1,150	10·5	B. & W.	85	S
27	[illegible]	1884–1919	300	40·6	20	4,500	640	7·3	Sulzer	200	T
28	[illegible]	1921	304 9	42	19 3	3,000 D.W.	1,650	11·0	Werkspoor	110	S
29	[illegible]	1922	307	47		4,000 D.W.	1,150	9·5	B. & W.	125	S
30	[illegible]	1921	321	48		5,200 D.W.	500	6·0	Krupp		
31	[illegible]	1921	330	46	22·5	7,713	2,20	11·5	Werkspoor	135	T
32	Augusta	1891–1920	330	42·2	24	5,000 D.W.	800	8·25	Sulzer	130	S
33	[illegible]	1913	350	47·2	24·5	5,600 D.W.	1,150	10·5	Neptune	135	T
34	[illegible]	1912	350	50	25 6	6,000 D.W.	1,700	11 0	Sulzer	160	T
35	[illegible]	1921	350	49·75	23	5,000 D.W.	1,100	10·0	Fullagar	125	T
36	[illegible]	1921	354	49	24	7,900	500	6·5	B. & W.	180	S
37	[illegible]	1910	354 6	55	24·7	10,055	3,300	12·0	Polar	120	T
38	[illegible]	1912	362	51·25	23·1	9,625	1,700	11 0	B. & W.	140	T
39	[illegible]	1915	365	50	23·4	5,800 D.W.	1,700	11 0	B. & W.	140	T
40	[illegible]	1922	365	49	23·25	5,480 D.W.	1,700	11 0	Neptune	125	T
41	[illegible]	1922	367	51·25	24 7	10,450	1,500	10·5	B. & W.	150	T
42	[illegible]	1921	370	48·25	24·25	6,500 D.W.	2,500	11·5	Sulzer	100	T
43	Salerno	1920	375	51 25	23	9,770	2,100	11·0	Werkspoor	120	T
44	[illegible]	1918	378	50·6		11,280	2,200	11 0	Ansaldo	100	T
45	Oljaren	1922	380 3	55	24·1	7,500 D.W.	1,850	11·0	B. & W.	130	T
46	[illegible]	1917	385	52	26	7,520 D.W.	2,100	11 0	B. & W.	125	T
47	[illegible]	1922	385	53·4	25·25	8,300 D.W.	1,870	10·5	B. & W.		T
48	[illegible]	1912	386	53	23·5	10,000	2,100	10·5	B. & W.	140	T
49	[illegible]	1914	395	53	24	10,550	3,200	12·5	B. & W.	100	T
50	[illegible]	1913	400	53		7,9000 D.W.	2,400		Krupp	135	T
51	[illegible]	1913	404	52·5			1,650		Carels	90	S
52	[illegible]	1920	405	54		13,600	2,400	11	B. & W.	110	T
53	[illegible]	1913	405	54·2	23·3	11 040	2,000	11	B. & W.	140	T
54	[illegible]	1922	405 25	55	28 1	13,858	2,000	11	B. & W.	140	T
55	[illegible]	1913	410	55		13,200	2,700		B. & W.	125	T
56	Handicap	1921	415	54·2		9,0000 D.W.	2,700	11 0	Sulzer	100	T
57	Yngaren	1921	420	54	25·5	9,3500 D.W.	2,150	10·5	Doxford	77	S
58	[illegible]	1921	425	56·7	26	14,000	2,500	10·5	Vickers	118	T
59	[illegible]	1920	425	56	26·7	13,800	2,300	11	B. & W.	125	T
60	[illegible]	1922	425	55	25	15,000	2,300	11	B. & W.	125	T
61	[illegible]	1922	445	59·7	28 5	16,500	3,200	11·5	B. & W.	115	T
62	[illegible]	1921	445	60	28 4	17,100	3,500	11·5	B. & W.	115	T
63	[illegible]	1920	445	60	32	18,000	3,500	11 5	B. & W.	115	T
64	[illegible]	1921	450	58	25 1	14,700	3,300	12·0	M.A.N.	230–85	T
65	[illegible]	1918	450	55·5			4,500	14·0	B. & W.	120	T
66	[illegible]	1922	450	58	27·9	11 0000 D.W.	3,800	13	N. British	96	T
67	[illegible]	1920	450	57		17,000	2,700	11 5	Bethlehem	100	S
68	Hauraki	1921	450	58	25 6	11 0000 D.W.	2,900	12	N. British	96	T
69	[illegible]	1921	450	57		12 0000 D.W.	3,240	11·12	B. & W.	115	T
70	[illegible]	1920	455	56		15,000	5,000	14	M.A.N.	130	T
71	[illegible]	1920	485	62	29 5	15,000	4,000	12·5	B. & W.	115	T
72	Zygos	1920	525	66 2	27 6	22,000	3,000	10·5	Krupp	106	T
73	[illegible]	[illegible]	550	72		21,000 D.W.	4,300	11 5	B. & W.	115	T
74	[illegible]	[illegible]	600 O A	72		32,000	14,000	17·18	Sulzer	135	T

[illegible]

D.W. denotes dead weight capacity, or displacement.
B.H.P. denotes Brake Horse Power.
B. & W. denotes Burmeister & Wain.
M. & S. denotes Mirrlees & Sevenson.

NOTES FROM THE FOREIGN PRESS.

Specially abstracted for "The Marine Engineer and Naval Architect."

Rapid Method for the Calculation of Displacement.

The desire to eliminate uninteresting and cumbersome methods of calculation especially in the design stage has produced many interesting departures from the usual stereotyped displacement sheet. The method recommended by the author of this article makes use of the planimeter in rather an interesting manner. The vessel's waterplanes are drawn on a contracted scale and the area corresponding to the rectangle forward of the vessel's extreme beam and length is calculated, and by running the planimeter round this rectangle a constant is obtained which at once serves as a check on the planimeter constant and combines the scale constant of the drawings. This constant holds good for the planimeter readings of all the waterplanes and thus the curve of waterplane areas is simply constructed. This curve is progressively integrated to obtain the total displacement, and this in turn is checked by a further constant obtained from the rectangle formed from the maximum draught and an ordinate corresponding to the area of the previous waterplane rectangle. The same idea is extended to the calculation of height of centre of buoyancy, the centroid of waterplanes, the longitudinal position of the centre of buoyancy, transverse and longitudinal metacentric radii. The method is good in so far as it eliminates numerical calculation, and the particular basis rectangle adopted is an improvement on the more usual practice of taking any circle or square for the checking of the accuracy of the planimeter. *M. Codebo, La Marina Italiana*, February, 1923. p. 48 ; 4 pp. ; 6 ff.

A Design for a New Type of Aircraft Carrier.

The study of the aircraft carrier problem is evidently engaging international attention. The most recent contribution appearing in the Italian press is distinctly bold in its aims and conception. Italy herself because of her particular geographical situation, has but little need for aircraft carriers whose primary function are, of course, to increase the autonomy of ocean-going aircraft. Aircraft carriers must possess speed, internal volume and uninterrupted deck space. With these conditions the designer is compelled to adopt a long, beamy, shallow draught high-freeboard vessel. This type in turn would involve ordinarily a hull weight which would absorb practically the whole of the otherwise available displacement. To eliminate this serious defect and to make the whole design possible, the author of this article ingeniously proposes to divide the ship into three distinct portions, the two end portions being connected by link work to the centre portion. The vessel considered has a length b.p. of 210 m., beam ex. 30 m. (beam on w.l. 28 m.), draught 3 m., displacement 12,000 tons, block coefficient 0·66, depth to flying-off deck 16 m., a speed of 22 knots with an estimated horse-power of 1,600 (*sic*). In the central portion are placed the main machinery and pumps for trimming the respective portions. Down in the after portion electro-motors directly connected to four propellers are fitted. Each portion forms a hangar, and provision seems to be made for stowing seven large hydroplanes and about 20 smaller scouts. The funnel uptakes, &c., are on the starboard side of the ship and thus a clear flying-off deck is obtained. In addition to the less common features already described, the proposed craft seems to embody the experience derived from existing vessels. The author's aim in publishing the article seems to be that of promoting a discussion on the subject, and in view of its importance this aim would seem likely to be realised.—*G. Rabbeno, Rivista Marittima*, January, 1923, p. 49 ; 8 pp. ; 2 ff.

Oil Burning under Boilers.

For at least forty years the German Admiralty have experimented with oil-fired boilers, but only comparatively recently have German merchant ships been designed or converted to burn oil fuel. The naval experience of many firms, together with the attractive possibilities of economy, is enabling reliable oil-burning arrangements to be profitably fitted in an increasing number of vessels. In this article the Thiessen system is described, and after enumerating the qualifications that a reliable system should possess, the author shows how the Thiessen system fulfills all requirements. These requirements are worth noting. The principal requirement is good spraying of the oil and mixture with the incoming pre-heated air. The fuel nozzles must be so designed as to be simply dismounted, exchanged and replaced. The boiler furnace must be easily accessible for overhaul cleaning and repair. The oil burning arrangement must be so designed as to admit of rapid conversion to coal burning should economic circumstances demand. The arrangement should have an auxiliary starting gear to ensure rapid starting when no other boilers are available under steam. The arrangement should be compact and capable of almost complete erection in the shops. Care should be taken with the cleaning of the oil. Care should be taken in the designing of all parts that they can freely expand and thus avoid all heat stresses. The pipe leads should be as simple as possible consistent with good control. In parallel arrangements the length and design of the connecting pipes should be controlled to avoid the formation of air pockets, &c., in the pipes. Messrs. Thiessen's system conforms to all of the above conditions and is at present built in three distinct sizes. It is very completely described in the article, and complete digrams illustrate fully the various parts.—*Dr. J. Eggers, Schiffbau*, November 15, 22, 29, 1922, p. 97, 128 ; 9 pp. ; 8 ff.

Shipbreaking Enterprises.

Owing to the requirements of the Peace Treaty demanding the breaking up by Germany of its submarines within three months of the ratification of the Treaty, she was able to lay the foundations of what is now probably an established shipbreaking industry. Altogether some 25 shipbreaking firms exist in Germany, the majority of these having plant specially designed for the demolishing as opposed to the building of ships. In this article the commercial possibilities and details of the industry are reviewed. At present some 30,000 to 40,000 tons of scrap per month are forthcoming from German shipbreaking firms, and the requirement of the steel makers is estimated at about 170,000 tons per month. Scrap is obtained from many sources and there is apparently a definite danger of over-production in the breaking yards. This fact, together with the fact that the price per ton displacement of old warships increased from 1921 to 1922 from 10s. to practically £3 per ton, is seriously affecting the industry. Warships are apparently the most remunerative, for at present merchant ships can hardly be demolished at a profit. The financial side of a shipbreaking firm is quite different from that of a shipbuilding firm. Much greater outlay is necessary in the former and much difficulty in securing credit is experienced as the risk is so much greater. The ultimate control of the shipbreaking yards will inevitably be taken over by the steelmakers, and by careful organisation under those conditions, it is possible that the industry could be permanently established.—*E. Steinbach, Werft, Reederei, Hafen*. December 7, 1922, p. 764 ; 2½ pp.

Movable Shipyard Cranes.

The present tendency in ship construction towards the fabrication of the structure under cover, and its subsequent erection in increasingly larger units, is definitely changing the transport organisation of shipyards. Portal cranes, cable gantries and movable tower or hammer head cranes are being increasingly adopted. Of these probably the most convenient, and hence popular, type is the movable tower crane. The Maschinenfabrik Augsburg-Nürnberg A.G. have specialised in this type of crane, and in this article some of their products are described. The construction of the cranes is especially light and as a result the cranes are relatively cheap. The cranes can be adapted for any size of shipyard, the height of the tower being appropriately designed to work in with the maximum height of ship. One crane can be made to serve two berths, and their large radius of action obviates the necessity for frequent bodily movement of the crane. Owing to the long length of lifting wire the object being lifted can be very easily manipulated. The hoisting machinery and motors are placed in the rear of the crane

[illegible] thereby ensuring the obtaining necessary amount of balance [illegible]. *Schiffbau*, March 7 & 14, 1923; p. 383; 2 pp.; 3 pp.

Temperature Measurement on Shipboard.

It is becoming increasingly recognised that careful control of temperatures is of considerable economic importance in the operating of a vessel's main and auxiliary engines. This recognition has brought about the development of electric distance thermometers, such as the system of the products of Siemens & Halske, Berlin, as described. The applications of distance thermometers are essential. The temperatures of the various parts of a boiler furnace, main engine cylinders, &c., are of obvious importance. Bearing temperatures have not usually been measured in the past, but are also obviously important for the central of lubrication. In the engine room all important temperatures can be immediately obtained from a central temperature control board by merely moving an indicator switch. The advantages of central control over the old system of thermometer pockets is obvious. Apart from the engine room many other applications exist on shipboard. For instance, it is necessary to know the temperature at important parts of refrigerating machinery, and especially in refrigerated and cool chambers where access for purposes of temperature control is undesirable. In passenger vessels the temperature of state rooms can also be controlled if necessary. One further important application in vessels burning coal is the control of bunker temperatures. By ordinary methods this is impossible, but by electric distance thermometers any dangerous rise in temperature may be made immediately visible. At the present time, when the necessity for the elimination of waste is [illegible] economical, there can be no doubt that electric thermometry will play a very important part in cutting down running expenses. *Hut. Schiff.*, February 23, 1923; p. 48; 2 pps.; 5 ill.

Shipyard Machinery.

In a special number of the *Schiffbau* devoted to shipyard machinery, a series of articles describe the developments which have taken place during the last year in German practice. In an article by Oberingenieur Nückel some of the newer products of Wagner, of Dortmund, are described. A plate planing machine with compressed clamping gear forms an interesting feature. Instead of the more usual hydraulic or mechanical clamping it is claimed that by compressed air the adjustment and clamping of the plate can be much more rapidly carried out. Another feature of this machine is the high-speed motor drive of the planer. This high-speed drive is not only ordinarily more economical than the usual low-speed type but also considerably reduces the idle stroke of the planer. This article further deals with improved frame and plate joggling machines.

Another article by Oberingenieur Stotz describes the steel-cutting saws of Wagner, of Reutlingen. These saws are useful for cutting sections, crankshafts, mast bands, and the finishing off of castings. Various types of saws are described, and also various types of mechanical saw tooth sharpeners.

A third article describes the shipyard wood working machinery manufactured by Kurchen, of Leipzig. Many interesting types are dealt with, band saws, planing machines, sandpapering machines, and also a special machine for making wood gratings. The series of articles have been written to illustrate some of the latest German products now on exhibition at the Leipzig Fair. *Schiffbau*, February 14, 28, 1923.

THE FIRST BIG FRENCH VESSEL EQUIPPED WITH DIESEL ENGINES.

Two Sulzer four-cylinder Engines of 1,700 b.h.p.

The Chantiers de la Loire are completing in their Nantes yards, to the order of the Chargeurs Réunis, the first French merchant motorship of large tonnage; this is the cargo-vessel *Camranh*, of 11,700 tons deadweight. The propelling machinery of this vessel has been built by Sulzer Bros. at their Winterthur works, and a photograph appears on page 127.

The main propelling machinery consists of two Sulzer four-cylinder two-cycle marine engines, each developing 1,700 b.h.p. The cylinders are 680 mm. bore and 1,100 mm. stroke. The total weight of each engine is 192 tons. An electric generating plant is installed, comprising two 410 b.h.p. four-cylinder Sulzer two-cycle engines, driving dynamos at 200 r.p.m. and also a 30-h.p. semi-Diesel set as auxiliary. The current generated is used to drive the other auxiliary plant.

There are two 200 h.p. electric motors, each driving a turbo-blower running at 2,550 r.p.m. and delivering 5 cubic-meters of air at a pressure of 0·115 kg. per sq. cm. Each of these blowers can supply the scavenging-air required for both the main engines when running at full load. There are also two 26-h.p. Sulzer centrifugal pumps electrically driven, for supplying the cooling water to the engines, and an auxiliary Worthington lubricating oil-pump worked by compressed air, the main lubrication being obtained from pumps driven by the engines themselves. A small emergency compressor is fitted and this is driven by a 6-h.p. Sulzer semi-Diesel engine.

Trial Results.

[illegible] carried out on the engines in the Sulzer works at Winterthur, and records were kept of the power absorbed by the auxiliaries, so that it was possible to estimate accurately the total consumption of fuel in the main engines and also the fuel used by all auxiliaries.

The lubricating oil consumption for cylinders and hand lubrication amounted to less than 0·3 per cent. of the fuel consumption or about half a gallon per hour for both engines when developing 3,400 s.h.p. The overload capacity was tested on one of the engines; [illegible] 2,500 s.h.p. [illegible] Slow running tests were also [illegible] at 27 r.p.m. The tests were carried out in the presence of representatives from the owners and of the Bureau Veritas.

The following is a summary of the results obtained:

SUMMARY OF TRIALS AT FULL LOAD.

		Starboard Engine	Port Engine
[illegible]		84	84
[illegible]		58·26	58·36
I.H.P. [illegible]		1,730	1,710
I.H.P. [illegible] for blowers and pumps ..		82·1	82·1
[illegible] per B.H.P. hour of main engines	lb.	0·024	0·022
[illegible] per I.H.P. hour [illegible]	lb.	0·375	0·384
[illegible] per B.H.P. hour	lb.	0·399	0·407
[illegible]		1·5	1·5
[illegible]		7	7
,, ,, (pistons)		30	30
[illegible]		20	20
[illegible]	lb. sq. in.	130	130
[illegible]		900	920
[illegible]		16	16
,, ,, ,, Cylinder outlet ..		100	100
[illegible]		115	122
Temperature of exhaust	deg. Fahr.	450	440

SUMMARY OF TRIALS AT REDUCED LOADS.

		¼	½	¾
[illegible]		¼	½	¾
Load ..		77·4	65·1	73·9
[illegible]		1,283	895	1,1
I.H.P. [illegible]		66·2	45·5	9 6·-
[illegible] per I.H.P. hour [illegible]		0·85	0·92	0·450
[illegible] per B.H.P. hour of engines		0·024	0·032	0·023
[illegible] per I.H.P. hour	lb.	0·411	0·429	0·406

RECENT PATENTS RELATING TO MARINE ENGINEERING.

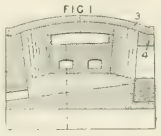
Compiled by E. P. Alexander & Sons, Chartered Patent Agents, 306, High Holborn, London, W.C.

No. 189,660. Furnaces.

Razen, Schaefer, et Cie and Schaefer, H., 3, *Rue Génistre, Luxembourg. December* 13, 1921, *No.* 33502. [*Classes* 51 (i) *and* 51 (ii).]

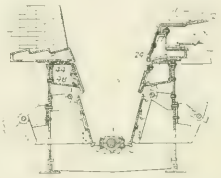
The parts of Martin or metallurgical furnaces subjected to high temperature are made by pugging refractory material in a wooden mould which is burnt away by putting the furnace into operation, leaving the refractory material in a solid block. Fig. 1 shows a Martin furnace of which the end walls containing the fuel and air ports and the arch 3 and walls 4 are formed as above.

FIG 1



No. 191,378. Furnaces.

Westinghouse Electric Manufacturing Company, East Pittsburg, U.S.A.—(*Assignees of Baum, J. V.*: 6039, *Pine Street, Philadelphia, U.S.A.*) *December* 22, 1922, *No.* 34981. *Convention date, January* 7. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 51 (i).]



The formation of clinker is prevented by injecting aqueous medium into the fuel bed at points of incipient clinker formation. The method is described in connection with an underfeed stoker comprising series of tuyeres 11 with intervening retorts 12 and a clinker pit 15. Mounted in channels in the sloping faces of air boxes 17, 44 on opposite sides of the pit are distributing headers 24, 48 through which water or steam or mixtures thereof, and it may be air also, is discharged into the burning refuse. The header 48 may be omitted where the pit is of comparatively small width.

No. 189,550. Ejectors.

Fink, M. W., Nesta, Esplanade Avenue, Brighton Beach, near Melbourne, Australia, September 2, 1921. *No.* 23389. [*Class* 71.]

Apparatus for creating vacuum in a chamber 27 by means of an ejector comprises a pipe 1 connected by a union 2 with a bulb 3 in a second pipe 4, which is in turn connected by a coupling nut 6, Fig 3^a, to a chamber 7 containing the ejector 15, 16 and communicating with the vacuum chamber by means of a pipe 22. In the delivery pipe of the ejector are arranged an agitating device 37 and a cock 20, and in the pipe 22, a side branch 28 of which communicates with a manometer 29, a number of valves, 23, 25, 26, to prevent access of the working fluid of the ejector to the vacuum chamber and a number of centrally perforated washers 25^a are arranged. The power jet 15 of the ejector screws into the chamber 7, Fig. 3^a, and a centrally perforated washer 12 is clamped between this jet and the nut 6. The tail member 16 of the ejector is also screwed into the chamber 7, adjustment thereof being effected by a coupling-nut 39 connecting the chamber 7 with the agitator container 19.

FIG. 2.

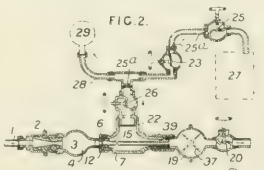
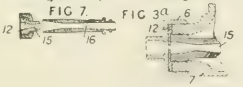


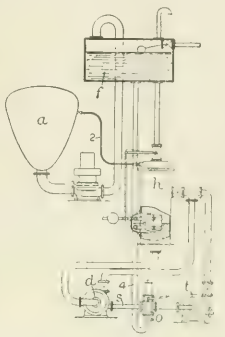
FIG 7. FIG 3a



No. 191,332. Steam Generators.

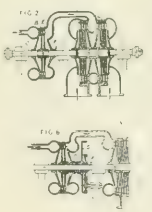
Weir, Limited, G. & J. and Weir of Eastwood [*William Douglas*], *Baron, Holm Foundry, Cathcart, Glasgow. May* 31, 1922, *No.* 15294. [*Class* 123 (ii).]

In a boiler feed-supply system comprising a condenser, a condensate extraction pump, an atmospheric feed tank, a direct contact heater or its equivalent, a booster pump and a feed pump, the heater *h* is arranged between the feed tank *f* and the booster pump *d*, and a vacuum is maintained in the heater corresponding to the feed temperature, the heated feed being freed from air and non-condensible gases and delivered under pressure through a closed pipe to the feed pump *t*. Air and gases are drawn away from the heater through a small-bore pipe 2 opening into the condenser *a*. The water is heated by exhaust steam supplied to the heater from the pumps *d*, *t*. The pipe *s* between the pumps *d*, *t* is fitted with a loaded valve *o*, which opens when the pressure in the pipe rises above a certain point, and allows the feed to pass through a pipe 4 back to the feed-tank.



No. 191,360. Turbines.

Society Rateau, 40, *Rue du Colisée, Paris. May* 19, 1922, *No.* 14186. *Convention date, January* 7. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Class* 110 (iii).]



A fluid pressure turbine comprises two rotor wheels B, E to which steam or gas is supplied axially. Each wheel has a single ring of blades and the two are mounted on oppositely rotating shafts C, F revolving at different speeds, the rotor E preferably revolving at half the speed of the rotor B. The shafts carry other rotors for completing the expansion of the fluid such as a dual flow rotor L and the fluid may be led in series or parallel through the rotors on each shaft. The shafts may be geared together. Fig. 6 shows an arrangement of a co-axial sleeve shaft C^1, carrying an internally toothed wheel S^1, gearing with a toothed wheel on the shaft F.

No. 191,374. Turbines.

Metropolitan-Vickers Electrical Company Limited, 4, *Central Buildings, Westminster.*—(*Assignees of Kasley, A. T.*; 511, *Saude Avenue Essington, Pennsylvania, U.S.A.*) *December* 20, 1922, *No.* 34721. *Convention date, January* 7. *Not yet accepted. Abridged as open to inspection under Section* 91 *of the Act.* [*Classes* 80 (iv) *and* 110 (iii).]

An elastic fluid turbine employing low-pressure blading of the kind described in Specifications 182,775 and 183,429 has axial-flow and combined-flow stages, the latter having axial-radial blading. The condenser is supported from the turbine casing, which is mounted on special balanced levers.

FIG 1

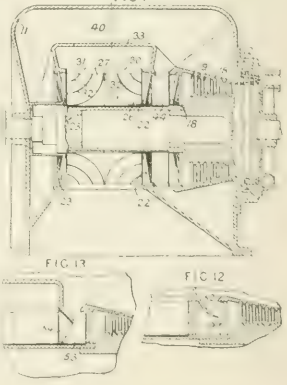


FIG 13 FIG 12

...is admitted through annular stages 42, Fig. 1, and thence through an axial stage of expansion blades 44, fixed to the casing. Guide vanes 18 and a row of special moving blades 44, form the stages, passing partly through annular spaces 22 to axial radial blades 26 and so to the outer annular space 11 to the final guide vanes 23 and axial radial blades 27 to exhaust. The blades 26, 27 have preferably hook-like terminations 30, 31 as described in Specification 183,429, and are provided with guides 32 to assist in changing the direction of the fluid and to reduce the velocity. The guide vanes 44 are formed as shown in Fig. 5 of three portions secured by welding or otherwise and engaging hooks 45. All inclined 16 for admitting steam and nozzle-like exit portions 43 for axially issuing steam, these portions being secured together by an annular angle bar 47. In a modified form the guide vanes 18, 22, 23 are arranged radially instead of being inclined, and in another form inclined guides may be fitted between and ... the blades 44 to assist in directing part of the steam radially, and to strengthen the structure. In a further modification both axial and radial exit passages of the blades 44 are formed in a hook-like fashion, the whole blade being formed in one piece. In this case also inclined guides may be fitted between the blades. In another form the steam from the last row of blades 19, Fig. 12, is divided into radial and axial portions by a conical annular member 52, while in a further form this effect is produced by a row of triangular moving blades 53, Fig. 13, and a row of triangular fixed vanes 54. The vanes 53, 54 have substantially straight portions with curved exit edges. The rotor-shaft is preferably supported by the turbine casing 11 as shown in Fig. 15, the casing being carried on four feet 56, 57, 58, 59, Fig. 16. The feet 56, 57 rest directly on a fixed support while the feet 58, 59 rest on pivoted levers 62, 63, Fig. 17, which engage each other at their inner end by a roller connection.

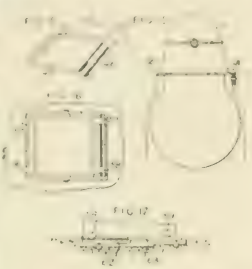


FIG. 17

No. 191,456. Water-tube Boilers.

... a Superheater ... Company, Limited, Fort Street ... and Rees, J., 42, Robertson Street, Glasgow, C. October 17, 1921. No. 26837. [Class 123 (iii).]

A water-tube steam generator having an ordinary furnace can be fitted for passing exhaust gases from internal combustion engines through tubes 7 in the water space of drum A. The tubes 7 may pass transversely through the drum.

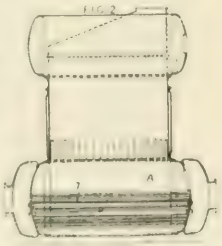


FIG. 2

No. 191,450. Furnaces.

... Ltd., 81, Chancery Lane, London. Deutsche Luftwaffe ... 21, Kaiser-Wilhelm-Allee, ... October 10, 1921. No. 26769. [Class 51 (i).]

Pressure air is supplied under the grate and the combustion products are deflected downwardly, as a Bunsen flame, through ... 28, on to a secondary hearth and ... The secondary air enters through, and thereby cools, the furnace ... into the ash-pit 37 and enters ... through ... 45 are arranged at the rear end ... and are supplied with ... secondary air, under pressure, through the damper 52. The combustion products may be filtered by closing the outlet 29 by an upright grate and placing coke, slag or the like in front of it. The secondary air may be supplied beyond the bridge 34. A passage 30 is provided through the arch 28 and acts as a vent when the pressure in the combustion space rises. The steam-jet 22, situated below the protection plate 23, is interconnected with the door 27, the jet being closed as the door opens. If a rotary blower is used the flap valve 25 is also connected to the door 27. The door 27 is connected to a lever 55 which is pressed home by a projection 59 on a weighted lever 56 and is retracted by a lug 61 engaging behind the lever 55. The shaft 57 is connected by levers to the steam-jet and flap valve.

FIG. 2

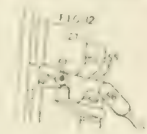


FIG. 2

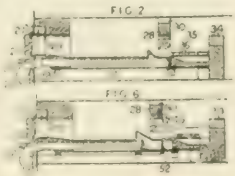
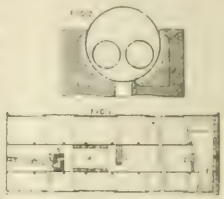


FIG. 6

No. 191,516. Furnaces.

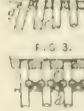
... Leather, J. H., 9 and 2, Calle Cinquentinel, Barcelona, Spain. October 29, 1921. No. 28730. [Class 51 (i).]



In steam-boiler furnaces an additional combustion chamber A is formed behind the fire-bridge B¹, comprising a fire-brick lining and a depending baffle C, and near the end of the flue a wall D serves to direct the combustion products upwards. Baffles E are formed in the side flues near the rear end of the furnace. Additional air for combustion is supplied through a chamber B in the fire-bridge by a damper *b*.

No. 191,309. Turbines.

Williams, W., 48, Rumbold Street, Rochdale. March 7, 1922. No. 6624. [Class 110 (iii).]



One or more taps or cocks 5 having an outlet of from one-eighth to three-quarters of an inch deliver water on to a jet wheel 2 having three or more skew blades carried between end plates. Balance wheels may be provided on the jet wheel shaft, at each end of which is an electric installation. A metal cover is provided for the jet wheel.

No. 191,394. Water-tube Boilers.

Schmidtsche Heissdampf Ges., 2, Relenstrasse, Wilhelmshohe, Cassel, Germany. January 5, 1923. No. 476. Convention date, January 5, 1922. Not yet accepted. Abridged as open to inspection under Section 91 of the Act. [Classes 99 (i) and 123 (iii).]

To prevent excessive stresses in the drums of a high-pressure water-tube boiler due to transverse movements of the water tubes upon expansion and contraction, the ends of the tubes are surrounded by plates which prevent transverse movements and at the same time allow the tubes to expand and contract. Plates *f* around the ends of the boiler tubes *c* are each built up of bevelled bars *d*, *e*. The bars *d* pass between the tubes and rest upon the boiler setting and upon rings *g* on the tubes. The bars *e* are supported upon the bevelled faces of the bars *d* and have recesses receiving the sides of the tubes. The tube holes in the drums are recessed on the outside of the drums and are countersunk on the inside, thus avoiding stresses on the outer surfaces of the drum plates due to the expansion and contraction of the tubes.

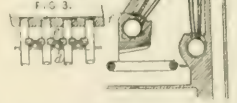


FIG. 2

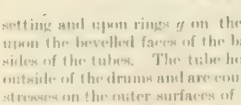


FIG. 1

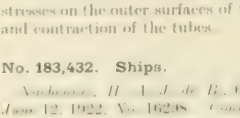
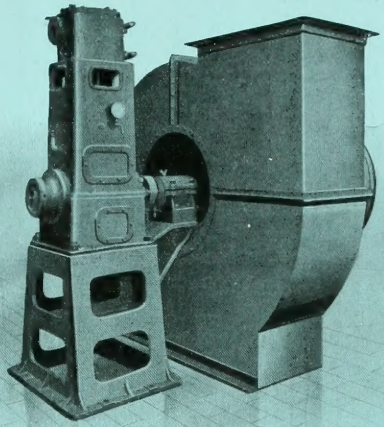


FIG. 3.

No. 183,432. Ships.

Nachenius, H. J. J. de H., 6, Frederikspark, Haarlem, Holland. June 12, 1922. No. 16248. Convention date, July 19, 1921. Addition to 175,861. Not yet accepted. Abridged as open to inspection under Section 91 of the Act. [Classes 113 (i), 103 (iii), and 114.]

The rear of a ship constructed as described in the parent Specification is provided with an horizontal extension 2 at the water level, such extension being adjustable in accordance with the water line variations, or alternatively, the stern is made concave so that the tangent to the upper part at the water line for maximum loading position is horizontal.



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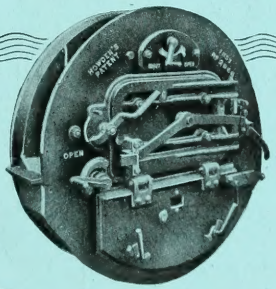

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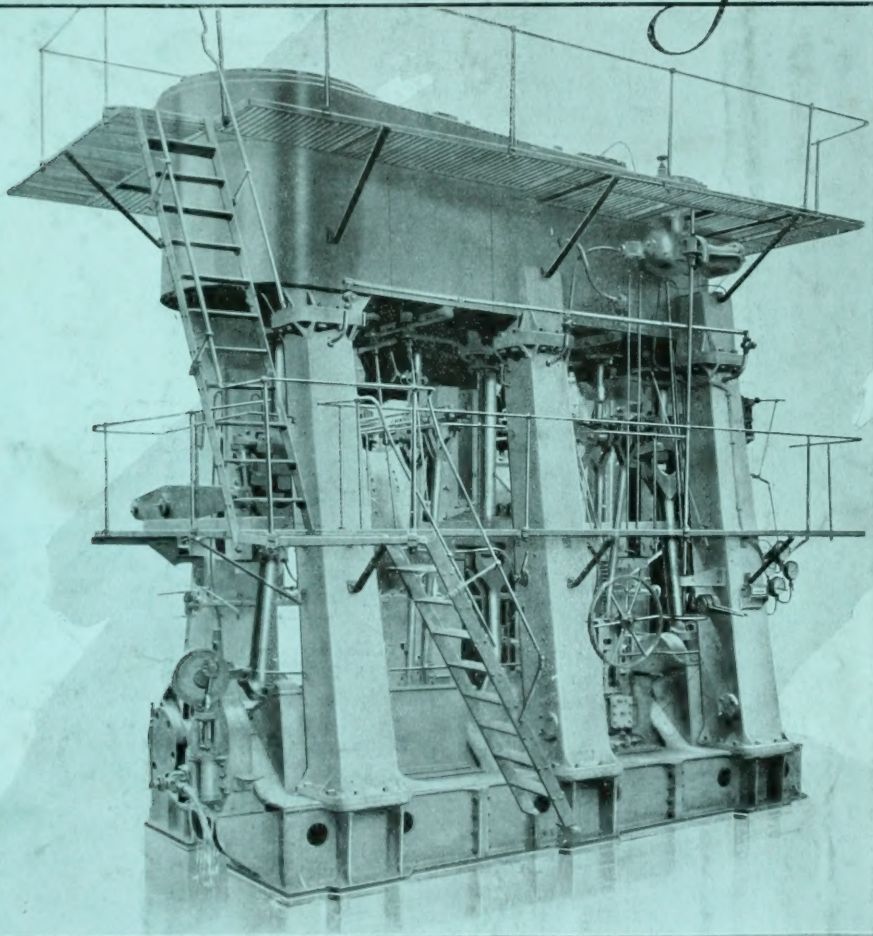

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